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16. ABSTRACT
This report is a documentation of an extended version of the executive computer program for the steady-state simulation of wastewater treatment facilities originally developed by Smith and Eilers of the EPA National Environmental Research Center in Cincinnati, Ohio. The program was developed as part of a technical and economic assessment of wet systems for residential refuse collection. This research includes an evaluation of the feasibility of joint treatment of sewage and ground refuse at modified wastewater treatment facilities, a task approached by development and application of the treatment simulation model described in this report. Major modifications to the original program include an extension from 20 to 50 quality parameters, the capability to accommodate 100 treatment processes and 200 streams as opposed to 25 processes and 25 streams of the original version, and incorporation of the most recently developed cost functions for most of the unit processes. New subroutines were developed by the authors for a number of preliminary and sludge handling processes, and some of the mathematical models of advanced waste treatment processes developed by other EPA contracts were adapted for inclusion into the revised executive program.

17. KEY WORDS AND DOCUMENT ANALYSIS

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MODIFICATIONS TO THE EXECUTIVE COMPUTER PROGRAM FOR STEADY-STATE SIMULATION OF WASTEWATER TREATMENT FACILITIES

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REVIEW NOTICE

The National Environmental Research Center--Cincinnati has reviewed this report and approved its publication. Approval does not signify that the contents necessarily reflect the views and policies of the U.S. Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

FOREWORD

Man and his environment must be protected from the adverse effects of pesticides, radiation, noise and other forms of pollution, and the unwise management of solid waste. Efforts to protect the environment require a focus that recognizes the interplay between the components of our physical environment--air, water, and land. The National Environmental Research Centers provide this multi-disciplinary focus through programs engaged in

- studies on the effects of environmental contaminants on man and the biosphere, and
- a search for ways to prevent contamination and to recycle valuable resources.

As part of these activities, the study described here presents an investigation to determine the feasibility of hydraulic transport of ground refuse in sanitary sewers of conventional design.

This report is one of several final reports examining the technical and economic feasibility of collecting and transporting residential solid wastes via an underground, wet pipeline (sewer) system. The research was aimed at improving the overall management and reuse of solid waste to the benefit of both the individual citizen and the national environmental picture. All possible aspects of this new concept were considered including the physical, mechanical, chemical, and socio-economic, and the environmental. It is the conclusion of the study that the wet system concept is extremely feasible technically, socially, and environmentally; but that the system's economics do not appear too reasonable at this time except for specialized applications.

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Director
National Environmental
Research Center, Cincinnati

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CHAPTER I

INTRODUCTION

The program described in this documentation report was developed as part of an investigation into the economic and technical feasibility of wet systems for residential refuse collection under Contract 68-03-0183 sponsored by the Solid Waste Research Laboratory of the EPA National Environmental Research Center, Cincinnati, Ohio.[1] A major focus of this investigation was to examine the economic and technical feasibility of treating ground refuse at existing or appropriately modified sewage treatment facilities, and to this end some form of mathematical model was considered desirable. Because the impact of adding ground refuse to sewage would primarily affect its quality rather than quantity, a basic prerequisite for the model was explicit consideration of sewage quality parameters in the determination of process costs. A second prerequisite was that the model should already be largely complete and proven, so that programming efforts could be minimized. Thus, the choice fell on the Executive Program developed by Smith and Eilers,[2,3,4] and this report describes the changes and additions that were made to that program. It is published separately from the other contract reports[1,5,6] because it may be of interest to a very different audience not necessarily concerned with the solid waste management implications of the research.

In order to keep the length of this report to acceptable limits, the assumption is made that the reader is already familiar with the program as developed by Smith and Eilers. In particular, it is recommended that the 1970 version of the Executive Program Documentation[2] be studied prior to a detailed reading of this report, and, if possible, the earlier reports by Smith[3] and Smith, Eilers and Hall.[4] This assumed familiarity with the program is especially important to an understanding of Chapter II.

Unit Processes Available

The original version of the executive program package[2] contained only 12 unit process routines, which was quickly found to be inadequate for the intended analysis of the wet systems study. Moreover, the program was structured in such a way as to limit the number of processes in any one treatment simulation to 25; yet an adequate simulation of the planned treatment plant in the case study area of Springfield, Massachusetts, required 31 individual unit processes, even without advanced waste treatment or the additions necessary to handle ground refuse. Thus it was necessary not only to restructure the program to allow many more unit processes to be included, but also additional routines were required to model many of the unit processes considered likely for joint refuse-sewage treatment. These additional routines were obtained from a variety of sources, or developed by the writers, as indicated on Table 1. This lists the Unit Processes, and the corresponding subroutine name and number, for which there is presently provision in the program.

Because of the specific focus on treatment of ground refuse in sewage, not all of the routines listed on Table 1 are complete. Some exist only as dummy routines; it was originally planned to develop these routines and provision for them was therefore made, but as the project progressed it was evident that they would not, in fact, represent reasonable treatment alternatives and further work on these routines was abandoned. The routine for paper fiber recovery is typical in this respect. Other processes, such as multi-media filtration, were considered worthy of consideration, but the level of effort required to produce a reasonable working model was considered beyond the scope of the wet systems contract.

Only small changes were made to the routines obtained from published sources or from EPA, and the writers make no claims that these routines (marked "X" or "EPA") are adequately proven for general application. A complete analysis of these routines would have been beyond the scope

TABLE 1: WASTEWATER TREATMENT UNIT PROCESSES

Subroutine Number	Source	Process	Subroutine Name
1	O	Preliminary	PREL
2	EPA	Influent Pumping	RWP
3	C	Bar Screens	BSCRN1
4	*	Flow Measurement	FLOW
5	C	Coarse Screens	CSCRN
6	C	Medium Screens	MSCRN
7	C	Fine Screens	FSCRN
8	C	Sewage Grinding	GRIND
9	C	Grit Chamber	GRIT
10	C	Grit Washer	WASH
11	C	Comminution	COMM
12	EPA	Holding Ponds	EQUAL
13	O	Mixer	MIX
14	O	Spliter	SPLIT
15	O	Primary Settler	PRSET
16	O	Activated Sludge	AERFS
17	O	Trickling Filter	TRFS
18	EPA	Post Aeration	POSTA
19	C	Biological Nitrification	BION
20	C	Biological Denitrification	BIODN
21	C	Breakpoint Chlorination	BKCL2
22	*	Luxury Phosphorus Uptake	LUXP
23	X	Lime Addition	LIME
24	X	Lime Recalcination	RECAL
25	X	NH_3 Stripping Tower	NH3S
26	*	Recarbonation Using CO_2	RECARB
27	X	Microscreening	MICRO
28	*	Multi-media Filtration	FILTER
29	C	Activated Carbon Adsorption	CARBON
30	X	Reverse Osmosis	RO
31	X	Electrodialysis	ELECT
32	*	Ion Exchange	IE
33	O	Chlorination	CHLOR
34	O	Thickener	THICK
35	EPA	Floatation Thickening	TFLOAT
36	EPA	Sludge Holding Tanks	SHT
37	O	Anaerobic Digestion	DIG
38	X	Aerobic Digestion	AEROBE
39	O	Elutriation	ELUT
40	O	Vacuum Filter	VACF
41	EPA	Centrifuge	CENT
42	O	Sand Drying Beds	SBEDS
43	*	Fluidized - Bed Incinerator	FLINC

Table 1 (continued)

Subroutine Number	Source	Process	Subroutine Name
44	EPA	Multi-Hearth Incinerator	MHINC
45	C	Landfill	LAND
46	*	Paper Recovery	PAPREC
47	*	Incinerator Residue Recovery	INCREC
48	EPA	2nd Stage Anaerobic Digestion	DIG2
49	X	Sludge Drying Beds No. 2	SBEDS2
50	C	Bar Screens No. 2	BSCRN2
51	C	Splitter No. 2 (Subsequent)	SPLIT2
52	C	Splitter No. 3 (Fixed Ratio)	FSPLIT
53	C	Sludge Haul	SHAUL
54	C	Cyclone	CYCL
55	C	Wet Oxidation	WOX
56	C	Sludge Pumps	SPUMP
57	C	Fixed Ratio Mixer	FMIX
58	C	Skimmer (Must Follow PRSET)	SKIM

* Skeleton Routines, Incomplete
X Routines obtained from other published sources, mainly EPA sponsored contract research.
C Routine developed and added by this contractor.
EPA Routines obtained from Mr. R. Eilers of EPA Cincinnati
O Routines in original Executive Program Version

of the contract, and consequently, efforts were solely directed toward compatibility with the remainder of the program so that inclusion of the process would in fact be possible.

Quality Parameters

The original executive program utilized 17 quality parameters, which were quickly established as inadequate for proper design of advanced waste treatment processes and for the design of preliminary and primary processes under the drastically changed conditions resulting from the addition of ground refuse. As shown on Table 2, numerous quality parameters were added, currently reaching a total of 40. The revised program has the capability of 50 quality parameters.

Because the major interest of the research was on the impact of ground refuse on conventional preliminary, primary, and secondary treatment processes, several quality parameters were added to characterize more adequately the very difficult nature of the input. The parameter NSS (normal suspended solids) was redefined as those solids previously labeled by Smith and Eilers[2,3] as total suspended solids (TSS), and are generally equivalent to those solids smaller than 20 mesh (0.83 mm, 1/32 in). The object of this redefinition was to differentiate between normal sewage solids (NSS) and the larger solids representing much of the ground refuse which are labeled GSS (gross suspended solids).

Because the amount of grit may increase substantially if ground refuse is added to sewage, a separate parameter, GRIT, was added to allow explicit consideration of this characteristic. Thus total suspended solids, TSS, is redefined as

$$TSS = GRIT + GSS + NSS \qquad [1]$$

The addition of ground refuse will result in a considerable increase in light floating matter that will require a substantial skimming operation during primary sedimentation. Floating matter, which, in the case that ground refuse were added to sewage, might emanate from cellophane packaging, garden trimmings and the like, is thus characterized by the new quality parameter FLOAT. FLOAT is not included as a component of TSS for reasons explained in Chapter III. These quality parameter ad-

TABLE 2: QUALITY PARAMETERS

Parameter	Label	Code
Stream Number	SMATX(1,I) =	I
Flow, MGD	SMATX(2,I) =	Q
Solid Organic Carbon, mg/l	SMATX(3,I) =	SOC
Solid Nonbiodegradable Carbon, mg/l	SMATX(4,I) =	SNBC
Solid Organic Nitrogen, mg/l	SMATX(5,I) =	SON
Solid Organic Phosphorus, mg/l	SMATX(6,I) =	SOP
Solid Fixed Matter, mg/l	SMATX(7,I) =	SFM
Solid BOD, mg/l	SMATX(8,I) =	SBOD
Volatile Suspended Solids, mg/l	SMATX(9,I) =	VSS
Total Suspended Solids, mg/l	*SMATX(10,I)=	TSS
Gross Suspended Solids, mg/l	*SMATX(11,I)=	GSS
Normal Suspended Solids, mg/l	*SMATX(12,I)=	NSS
Heat BTU/gallon	*SMATX(13,I)=	HEAT
Grit, mg/l	*SMATX(14,I)=	GRIT
Dissolved Organic Carbon, mg/l	SMATX(15,I)=	DOC
Dissolved Nonbiodegradable Carbon,mg/l	SMATX(16,I)=	DNBC
Dissolved Nitrogen, mg/l	SMATX(17,I)=	DN
Dissolved Phosphorus, mg/l	SMATX(18,I)=	DP
Dissolved Fixed Matter, mg/l	SMATX(19,I)=	DFM
Alkalinity, mg/l as $CaCO_3$	SMATX(20,I)=	ALK
Dissolved BOD, mg/l	SMATX(21,I)=	DBOD
Dissolved Organic Matter, mg/l	*SMATX(22,I)=	DOM
Ortho Phosphorus, mg/l as P	*SMATX(23,I)=	ORTOP
Ammonia Nitrogen, mg/l as N	*SMATX(24,I)=	AMO
pH	*SMATX(25,I)=	pH
Dissolved Calcium, mg/l as Ca	*SMATX(26,I)=	CA
Dissolved Magnesium, mg/l as Mg	*SMATX(27,I)=	MG
Dissolved Sodium, mg/l as Na	*SMATX(28,I)=	NA
Dissolved Potassium, mg/l as K	*SMATX(29,I)=	K
Dissolved Ammonium, mg/l as NH_4	*SMATX(30,I)=	NH4
Dissolved Chloride, mg/l as Cl	*SMATX(31,I)=	CL
Dissolved Bicarbonate, mg/l as HCO_3	*SMATX(32,I)=	HCO3
Dissolved Sulfate, mg/l as SO_4	*SMATX(33,I)=	SO4
Dissolved Nitrate, mg/l as NO_3	*SMATX(34,I)=	NO3
Dissolved Phosphate, mg/l as PO_4	*SMATX(35,I)=	PO4
Dissolved Iron, mg/l as Fe	*SMATX(36,I)=	FE
Dissolved Copper, mg/l as Cu	*SMATX(37,I)=	CU
Dissolved Zinc, mg/l as Zn	*SMATX(38,I)=	ZN
Dissolved Lead, mg/l as Pb	*SMATX(39,I)=	PB
Floatables	*SMATX(40,I)=	FLOAT

*Added or redefined

ditions should be found useful also by the general user not necessarily interested in ground refuse, because the design and performance of preliminary and primary treatment processes can thereby be more accurately modelled.

A second focus of interest of the study was the impact of ground refuse on advanced waste treatment. But in order to model these advanced waste treatment processes with some degree of realism, additonal parameters were needed for the dissolved constituents, as shown on Table 2.

CHAPTER II

PROGRAM STRUCTURE

Programming Details

Programming Logic. The program consists of a main calling routine, an input routine, a series of special operation routines, a series of subroutines for each of the unit processes, a cost routine and 3 printing routines. Only the main phase containing the calling program (and the variables in common) resides in core storage throughout the execution, and all other routines are contained in separate phases that are loaded into core storage as needed by overlays. The first subroutine phase is placed in core immediately following the main phase and each subsequent phase overlays the one already in core storage, i. e. the old phase is deleted and the new one loaded in its place from disk storage. In this way, the core storage required is determined only by the size of COMMON, the calling routine and the one largest subroutine that is loaded from disk, and in its present form the program requires a machine of 64K bytes of core storage. This contrasts to a 256K bytes core storage requirement were the entire program to be in core throughout execution.

Nonstandard Programming Features. The 360-DOS version of the program as developed by the writers contains a number of FORTRAN programming features that are nonstandard or not often encountered.

The main phase and all subroutine phases use the FORTRAN multiple return option to replace the large number of GO TO statements that would otherwise be needed. The three changed statements are:

In the calling routine	CALL XXXX (&700)	replaces CALL XXXX
In the subroutine	SUBROUTINE XXXX(*)	replaces SUBROUTINE XXXX
In the subroutine	RETURN 1	replaces RETURN

This example would cause program control to go to statement 700 on return from subroutine XXXX.

The method of overlaying employed uses the FORTRAN statements: CALL OPSYS ('LOAD', 'CUR1XXXX'), followed by the usual CALL XXXX, where XXXX is the subroutine name and CUR1XXXX is the phase name that contains the subroutine in question. The phase names are defined during the LINK EDIT operation.

The method used to reduce the amount of core required is the storage of all initial, interim, and final results on disk by means of the FORTRAN DOS direct accessing features.[5,7] This avoids the need for large arrays stored in COMMON that would occupy much of the available storage, and this allowed the program capability to be expanded to 50 quality parameters and 200 streams without increasing overall core storage requirements.

The actual direct accessing statements in the FORTRAN program and subroutines are DEFINE FILE a(m, d, f, v); READ (a' r, b) list; and WRITE (a' r,b) list. The symbol 'a' represents the desired data set reference number. The DEFINE FILE statement specifies the number of records (m), length of each record (d), format (f), and index parameter (v), for each data set or file desired. In the READ and WRITE statements the symbol 'r' is the record being accessed and 'b' is the number of a FORMAT statement. In addition, a number of job control cards are required to define the disk space. More detailed information on direct accessing procedures is available in the appropriate IBM manuals or in the standard texts on FORTRAN IV.

Modification of Iterative Program Structure. The original executive program version uses the EPS variable to control and terminate iterations once mass balance has been established. In the original version, the criterion for mass balance was for the values of the quality parameters in all the process streams (stored in the SMATX array) to differ from the values in the process streams at the previous iteration (stored in the TMATX array) by less than EPS, where EPS is defined in terms of mg/l. It became apparent, however, that the large solids concentrations in the sludge streams had the effect of needlessly extending the itera-

tions because EPS was defined in absolute rather than relative terms and therefore required precision levels to within one part in several hundred thousand as opposed to precision levels of one per hundred in, say, the effluent stream.

The revised version specified EPS as a relative precision level in the range $0 < EPS < 1$, typically 0.001 or 0.0001. This had the effect of reducing the iterations for large complex treatment configurations by a factor of 2 or 3. Sensitivity analyses showed the resultant cost and design data to be little affected, if at all. A further input variable, ITMAX, was also added to automatically terminate the iteration after ITMAX cycles.

Special Purpose Routines

The original program included only two special purpose routines, a mixer and a splitter, having the function of merging and splitting streams as would be done by valves and junctions in an actual plant. These routines needed to be augmented by three further special purpose routines as described below.

FMIX: Certain unit processes, such as the wet oxidation process for sludge incineration, may require their input to be a fixed proportion of two input streams, with any flow in excess of the specified proportion by-passing the process. For example, the wet oxidation process planned for the Springfield, Massachusetts, treatment facility calls for an input mix of primary to secondary sludge in the exact proportions of 0.49 to 0.51, and any excess of one or the other sludge type to be bypassed. Subroutine FMIX was therefore added to perform this function, with the input parameters DMATX(1,57) and DMATX(2,57) required to specify the proportions of the two input streams IS1 and IS2 in the output stream OS1, and with the flow in output stream OS2 defined as the flow from either input stream that is in excess of this proportion. For example, suppose that the output stream OS1 were to contain the input streams IS1 and IS2 in the proportions 0.3 to 0.7, and that the flow in IS1 were 0.4 mgd and in IS2 0.9 mgd. (See Figure 1.) Then the ratio of flows in the output stream is given by

$$\frac{q_1\ (1-\delta)}{q_2} = \frac{0.4\ (1-\delta)}{0.9} = \frac{0.3}{0.7} \qquad [2]$$

where δ is the fraction of q_1 that will enter OS2* (and bypass the subsequent process input given by OS1). Solving for δ one obtains

$$\delta = (1 - \frac{0.9 \times 0.3}{0.4 \times 0.7} = 0.035 \qquad [3]$$

---

*If it is q_2 that is in excess, then the indices of q_1 and q_2 in this equation must be reversed.

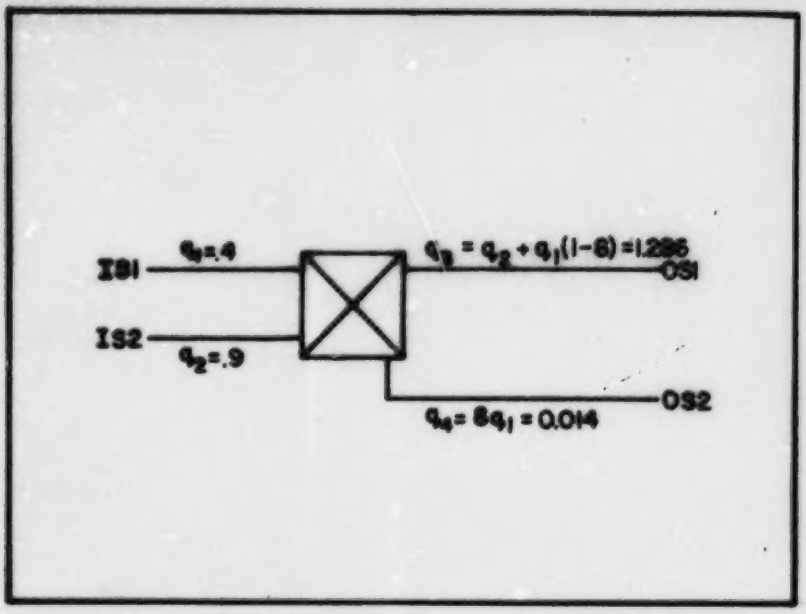


Figure 1: Subroutine FMIX

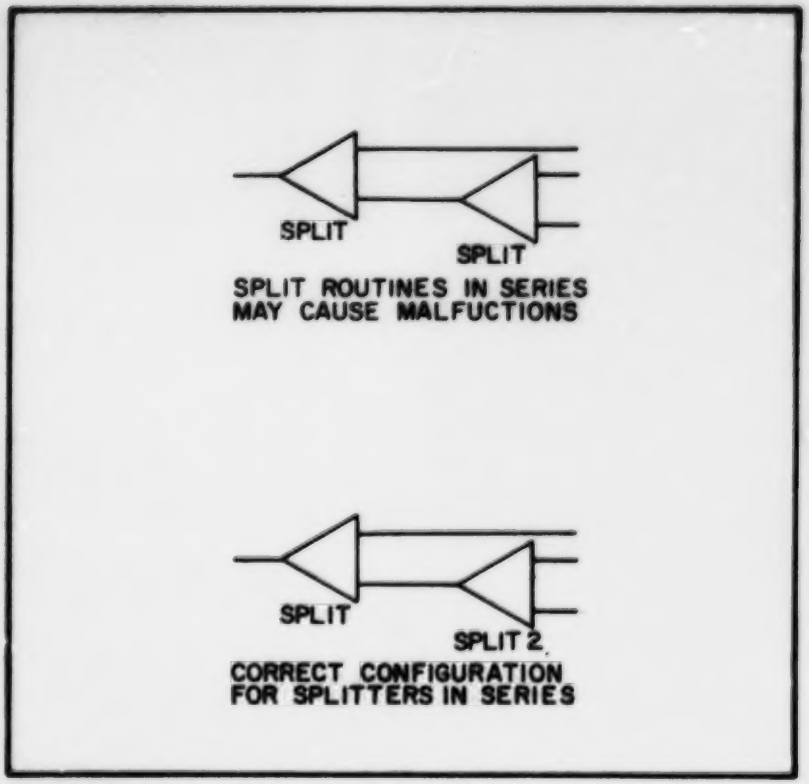


Figure 2: Subroutine SPLIT2

hence $q_3 = q_2 + q_1 (1 - \delta) = 1.286$ [4]

and $q_4 = \delta q_1 = 0.014$ [5]

SPLIT2: The original SPLIT routine was found to give difficulty when used in series in order to split, say, a single stream into three (see Figure 2). A modified routine, labelled SPLIT2, was therefore written for use whenever split operations are to occur in series. The reason for the malfunction of the original SPLIT routine when used in series is the backwards definition of the magnitude of the stream OS2; i.e. the process following the split operation defines the magnitude of the split stream.

FSPLIT: The original split routine defined the ratio of flows in accordance with the needs of the subsequent processes. However, it is also necessary to be able to split streams in fixed proportions, and for this purpose the routine FSPLIT was added. Suppose the flow Q_1 were to be split in the ratio λQ_1 to $(1 - \lambda)Q_1$ (see Figure 3). Then this can be simulated by use of the newly introduced FSPLIT routine (process number 52) in which the input parameter DMATX (1,52) is defined as λ.

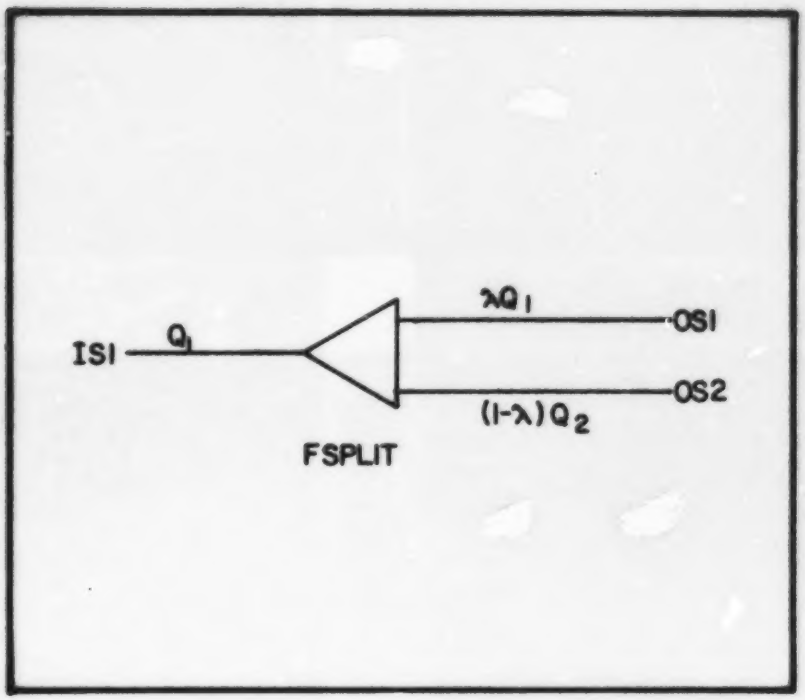


Figure 3: Subroutine FSPLIT

Input Cards: The card input to the revised program has remained unchanged, with the exception of the input parameters that are stored in the array DMATX. In the original Smith and Eilers version, these input parameters were read in following each process card. In order to minimize the card input of data that remains largely constant from run to run, these are now read from disk, where they are permanently stored by a small initializing program (see following section). Only if the newly introduced process card variable MREAD is set at 1 is DMATX read in from the subsequent 3 cards; otherwise, DMATX is read from disk and the 3 DMATX cards are omitted. Table 3 shows the revised Format of Data Input Cards and Table 4 shows the data input cards for the treatment plant illustrated on Figure 4. In this example, DMATX values are read from cards only for the process FSPLIT. This data is for a simulation of the existing Springfield, Massachusetts, wastewater treatment facility, with an input that corresponds to an addition to the Springfield sewage of 2.25 lb/cap/day of ground residential refuse.

Input Parameter Storage: As noted above, the DMATX input parameters are read onto disk by a small initializing program DMATREAD. These stored values are always used unless temporarily overriden by DMATX values read in from cards. However, the permanent values stored on disk may at any time be updated by rerunning the DMATREAD program with new input cards for that particular process.

Printed Output: Although the format of the printed output remains unchanged (see Chapter IV, sample executions), the method of calling the Print Routines has changed. The calling program now calls the routine PRINCO, which in turn calls either PRINT1, PRINT2, or PRINT3 according to the process number of the process

TABLE 3: FORMAT OF DATA INPUT CARDS

CARD	FORMAT	FUNCTION	VARIABLE NAME (S)
1	I2	Number of plant layouts to follow	NCASE
2	20A4	Title card	LIST(20)
3	11I4,5X,F5.2,5X,I3	Number of input streams, stream numbers, comparison value, iteration maximum	NIS,NN(10), EPS, ITMAX
4,5	8F10.3	Cost Parameters	(DMATX(I,100), I=1,16)
6	8F10.3	Fixed Quality Parameters	(DMATX(I,100), I=17,24)
7-13	8F10.3	Plant influent stream quality parameters	(SMATX(I,J), I=2,50)
		(Cards 7-13 repeated NIS times)	
14-		Process cards, one per unit process	K,N.IPROC,NAME(I),IN1,IN2, OUT1,OUT2,MREAD,III.
One set of three following each process card*	8F10.3,/8F10.3,/8F10.3	Input parameter cards	(DMATX(I,J),J=1,24)
Last	I1	End of deck card, must have a 9 punch	K

*Include only if MREAD on the preceding process card is set at 1; if MREAD=0 DMATX parameters are read from disk and the three DMATX cards must be omitted.

```
SPRINGFIELD, EXISTING PLANT, 2.25 LB/CAP/DAY
   1   1
                                                                  .01       010
176.1          120.        .06          25.          3.5          .15       1000.      .06
1.             .01
                                        7000.
36.            101.        60.          12.0         2.0          873.      146.       1643.
2517.          1027.       1027.        0.0          463.         73.       20.        20.
8.25           500.        250.         105.         320.         7.97      20.78      6.8
75.            25.         400.         20.          26.72        300.      100.       100.
23.            24.42       2.0          .5           .2           0.1       0.0        0.0
0.0
0.0            0.
0 01   03 BSCRN1    01                   03           02                                 2
0 02   09 GRIT      03                   06           07                                 2
0 03   11 COMM      06                   08                                              2
1      13 MIX       08          20       09                                              1
0 04   15 PRSET     09                   11           10                                 0
0      14 SPLIT     11                   22           23                                 0
0 09   52 FSPLIT    10                   12           04          1                      0
0.5


0 05   37 DIG       12                   13                                              0
0 06   48 DIG2      13                   14
0      13 MIX       14          04       21                                              0
0 07   39 ELUT      21          23       15           19                                 0
0 08   40 VACF      15                   16           18                                 0
1      13 MIX       18          19       20                                              1
0      13 MIX       02          07       05                                              2
0      13 MIX       05          16       17                                              2
0 10   45 LANDF     17                   24                                              2
9
```

TABLE 4: SAMPLE DATA DECK (corresponds to schematic of Figure 4)

TABLE 5: FORMAT OF DATA CARDS FOR DMATREAD

CARD	FORMAT	FUNCTION	VARIABLE NAME(S)
1	I2, 2X, A4	Process Number, Process Name	IPROC, NAME (IPROC)
2, 3, 4	8F10.3,/8F10.3, /8F10.3	Input Parameter Values	(DMATX(IPROC, J), J=1,24)
Repeated n times, one for each process			

Cost Functions. Whenever possible, the new program utilizes the cost functions recently developed by Black and Veatch, and the reader is referred to this report for details.[7] Where costs for some of the newly developed routines were obtained from other sources, they were brought to the same base year. The method of computing costs for yardwork, engineering, interest during construction, land and other miscellaneous costs are taken from a cost-estimating program developed by Eilers and Smith that is in turn based on the Black and Veatch data.[8] This report should be consulted for further details.

The method of updating costs to a particular level of the wholesale price index (for chemicals), the sewage treatment plant construction cost index (for capital costs), or the hourly labor and overhead rates (for operation costs) are also taken from this latter program.

Definition of Process Input and Output Labels. Each unit operation subroutine has a unique specification of input and output streams as shown on Figure 4. For example, the input stream to the activated sludge process routine, AERFS, is defined as IS1, the effluent as OS1 and the sludge stream as OS2; and the stream numbers corresponding to these inputs and effluents must be entered in the appropriate column of the coding sheet when setting up the data deck (see also Appendix D). The effluent streams on Figure 4 shown as a thick line indicate sludge streams.

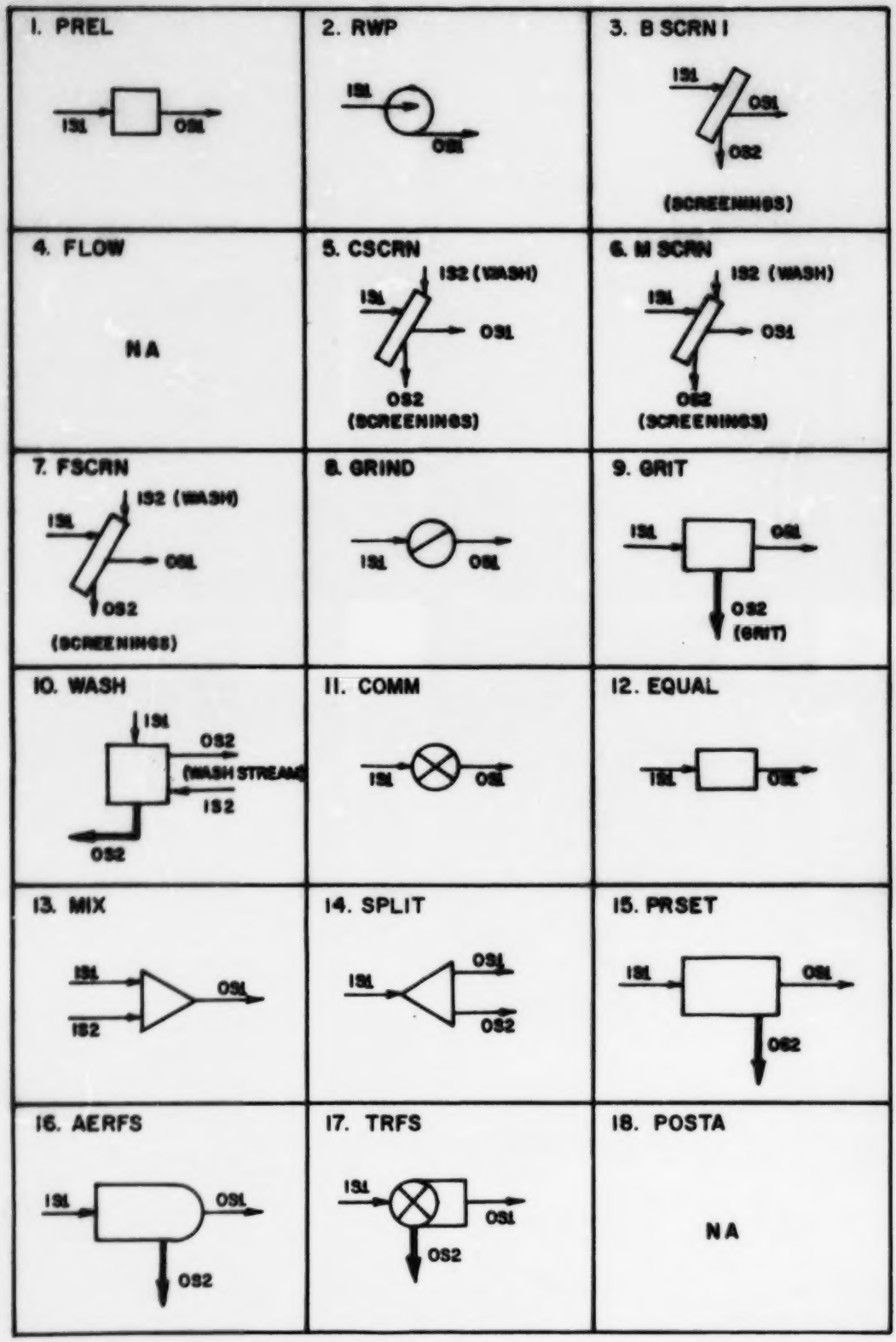


Figure 4: Input/Output Labels

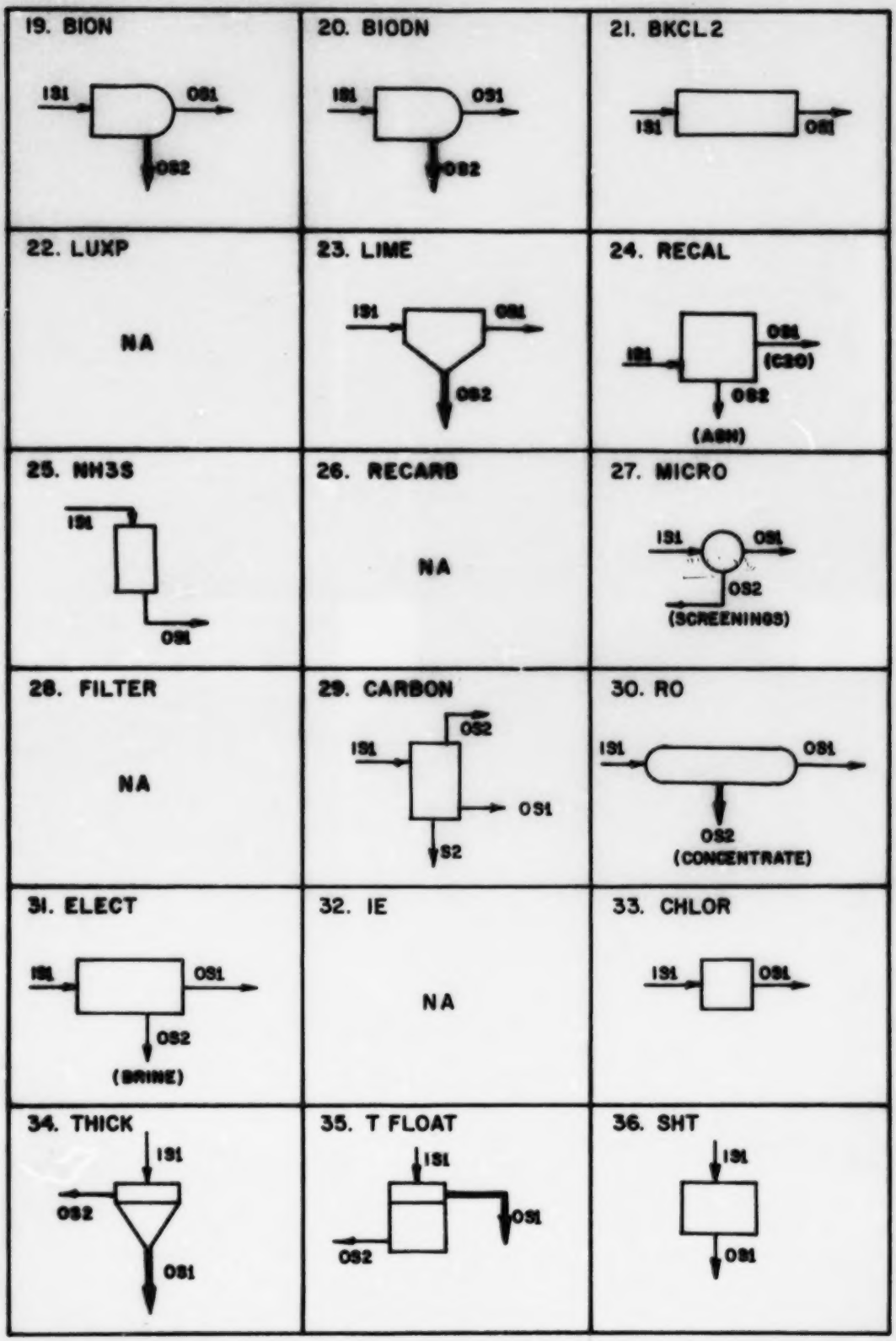


Figure 4 (continued)

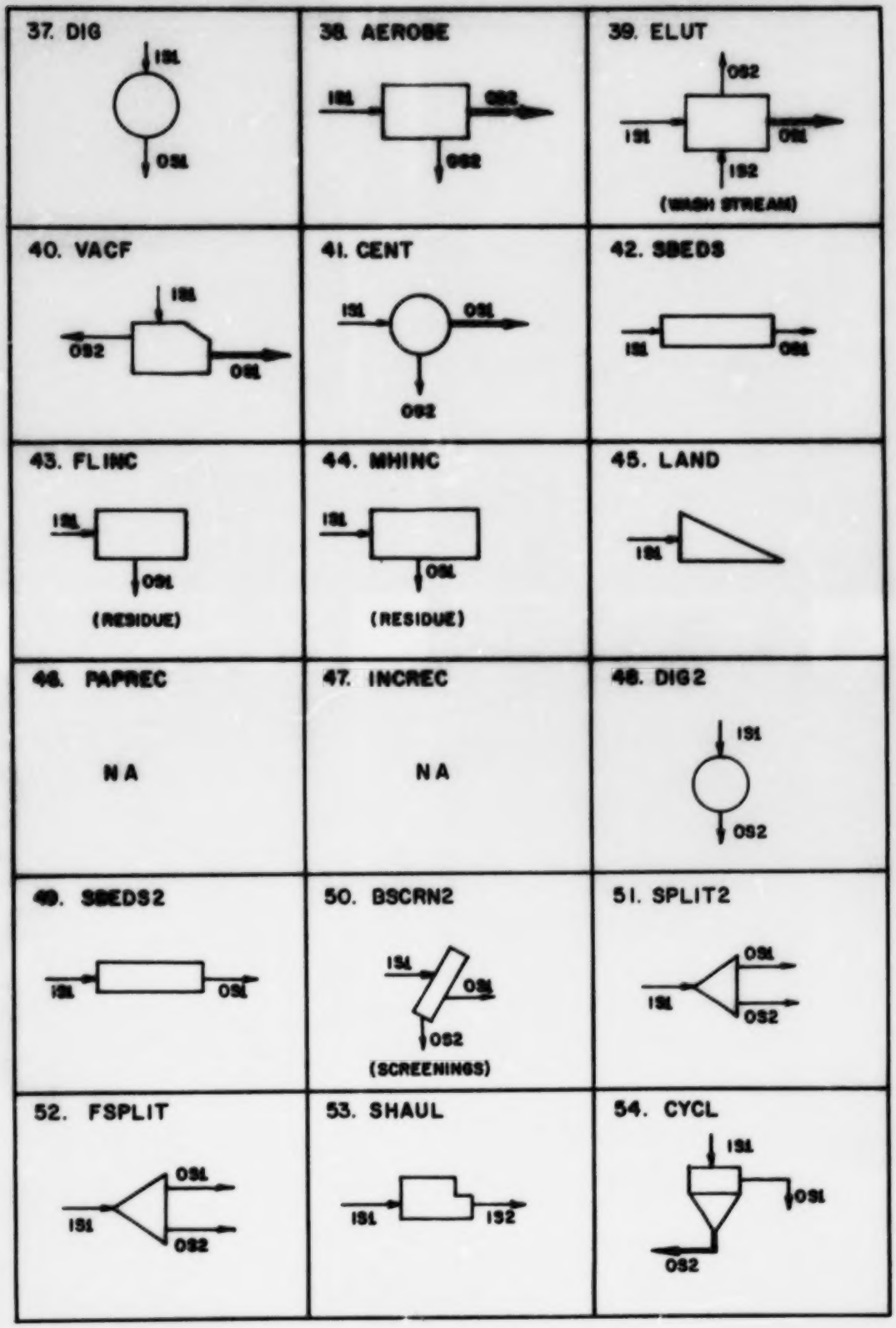


Figure 4 (continued)

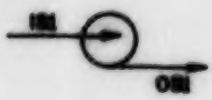
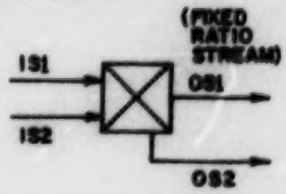
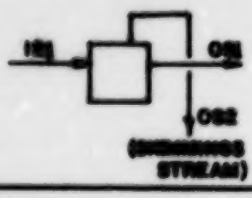
55. WOX	56. SPUMP 	57. FMIX 
58. SKIM 		

Figure 4 (continued)

CHAPTER III

DESCRIPTIONS OF NEW ROUTINES

Preliminary Processes

Bar Screens. Two bar screen routines were developed because two models were readily available. The first (Routine BSCRN1,#3) is based on the Storm Water Treatment Model with one set of design and cost equations.[9] The second (Routine BSCRN2,#49) is based on the ASCE Wastewater Treatment Plant Design Manual[10] supplemented by design and cost data supplied by the Link-Belt Co.[11] The program listing makes the design relationships used self-explanatory.

Screens for Suspended Solids Removal. Three screen subroutines were developed to allow screens of various pore size to be placed in series. In concept the three screens were sized at 4 (4.7 mm. 3/16 in), 20 (0.83 mm, 1/32 in), and 60 (0.246 mm, 1/100 in) mesh. Difficulties were experienced however because of the lack of information on the particle size distribution of the solids to be expected. An attempt was made to overcome these by specifying as decision parameters the amounts of GRIT, GSS, and NSS that can be removed by any screen process as a function of the concentration entering the plant, rather than the concentration entering the individual process.

The three processes use the same logic to determine the changes in the quality parameters brought about by the screen. Dissolved species are not removed by the screens and the amount of suspended species remaining is determined by the ratio of the TSS in each effluent stream to the TSS in the influent streams. It is assumed that the input rinse stream will be relatively pure, being recycled from the plant effluent. Therefore, it will contain no GSS, NSS or GRIT capable of being removed by these screens. The weight removed of the three constituents, WTGSSR, is obtained as follows, using GSS with a coarse screen as an example the equation is:

WTGSSR = (GSS to screen) (Q) (8.34 lb/gal) - [6]
(GSS into plant) (1-FGSSR) (Q into plant) (8.34 lb/gal)

hence, e. g.:

WTGSSR = (80 mg/1) (10 mgd) (8.34 lb/gal) - [7]
(100 mg/1) (1-.35) (10 mgd) (8.34 lb/gal)

WTGSSR = 6672 - 5421 = 1251 [8]

where FGSSR is the fraction of influent solids removed. Thus, 5421 lbs of the 8340 lbs fed into the plant could never be removed by any number of coarse screens in series. However, this screen will remove 1251 lbs of the 6672 lbs being fed to it.

The size of the coarse screen is based on maintaining a 3 ft/sec water velocity through the screen.

$$\text{AREA} = \frac{Q\ 1.54745}{3.0} = \frac{[\text{MGD}]\ \frac{\text{ft}^3\text{sec}}{\text{MGD}}}{\frac{\text{ft}}{\text{sec}}} = [\text{ft}^2] \qquad [9]$$

The cost relationship is based on some rough data from the paper industry covering screens used for similar purposes. Capital costs are assumed at $1,000/sq ft, and operating and maintenance costs are 1 percent of the capital costs.

The medium and fine screen models use the design and cost criteria as developed for the Storm Water Model which are based on the hydraulic loading (HYLD) and the flow.[9] The surface area required is:

$$\text{SCREEN} = \frac{Q\ 1000000}{\text{HYLD}\ 1440} \frac{[\text{MGD}]\ \frac{\text{gal}}{\text{Mg}}}{\frac{\text{gal}}{\text{ft}^2\ \text{min}}\ \frac{\text{min}}{\text{day}}} \qquad [10]$$

The capital costs are figured at $12000/MGD, and the operating and maintenance costs are 2 percent of the capital costs.

Size Reduction. Two processes are available for size reduction. One corresponds to a comminutor (Subroute COMM,#11) as used in conventional preliminary sewage treatment, and the other represents a grinder (Subroutine GRIND,#8) as might be used for size reduction of screenings. The design and cost relationships for both are based on data supplied by Link-Belt Co. and from the ASCE Sewage Treatment Plant Manual.[11,10] Both models are based on the assumption that only discrete sizes are available, and that some overcapacity will generally be present. The units have no effect on any quality parameter since they only reduce oversize particles in the GSS category to a smaller size but still defined as GSS.

The sewage screenings grinder is considered to be available in three sizes: 2000, 3000 and 4000 lbs/hr. Therefore, design is based on the lbs/hr of GSS feed into the unit. The comminutor is considered to be available in five sizes; 0.5-0.35, 0.15-1.2, 0.2-2.5, 0.8-11, and 1-26 MGD. For capacity requirements in excess of 26 MGD it is more economical to use multiple 26 MGD units in parallel rather than use several smaller units. Operating and maintenance costs are assumed to be 1 percent of equipment costs for both units.

Grit Handling. Two grit handling processes have been modeled. An aerated grit chamber is available for grit removal only (Subroutine GRIT,#9), and a grit washer is available to recover the organics lost through the grit chamber (Subroutine WASH,#10). These models are based on data supplies by Link-Belt Co. and the ASCE Sewage Treatment Plant Manual.[11,10] The grit chamber is designed on the basis of flow over the range of 1.5 to 25 MGD. Equipment costs are estimated by the function (0.4625) Q (MGD) + 7150, and operating and maintenance costs are assumed to be 2 percent of the equipment costs.

Although the dissolved quality parameters are not affected by grit removal, the amount of VSS and GSS removed with the grit are specified as input decision parameters. The assumption is made that all grit over 0.2 mm (65 mesh) in size is removed. The fraction of large grit

particles present in the influent, and the fraction of small particles removed are input decision parameters. This method was necessitated due to the lack of information on grit particle size distribution.

Grit washers are considered to be available only in discrete sizes and again over-capacity may be present. The five sizes used within this model are 20, 54, 67, 81, and 124 ft^3/hr. The process design depends upon the cu ft/hr of solids in both sludge and the wash streams. The densitites of the influent sludge stream and the washed grit stream are input decision parameters. The dissolved species are not affected by the grit washer. Operating and maintenance costs are assumed to be 1.5 percent of equipment costs.

Skimming. (Routine SKIM,#58) Because of the substantial increase in the quantity of floating matter when ground refuse is added to sewage, some explicit consideration of floating matter was found necessary. Unfortunately, individual unit operations are limited to two output streams and thus inclusion of a skimming operation, in, say, the primary settler is not possible as two output streams are already defined (the sludge stream and the liquid effluent). This difficulty was overcome by including the skimming operation into a separate routine, that normally follows the primary settler, and whose sole function is to convert a given fraction (DMATX(1,58)) of the input stream floating matter (i. e. SMATX (40,58)) into GSS. The skim stream consists of this GSS plus a certain weight fraction of the influent, as specified by the input parameter DMATX (3,58).

Sludge Haul. (Routine SHAUL,#53) The sludge haul routine is a set of simple arithmetical equations relating sludge volume per year to the number of trips necessary for trucks of given capacity and given travel speed and haul distance. The cost function is a linear function of the number of trips, the hourly operation cost, the capital recovery factor, the number of trucks and their initial cost, and the time per trip. Further details are given in Kos et al.[6], equations [53] - [61].

Landfill. (Routine LANDF,#45) As in the case of sludge haul, the landfill routine consists of a set of simple arithmetic operations relating volume of sludge to be filled per year to the required acreage, with costs expressed as a function of the per acre land cost and a per ton operating cost. Details can be again found in Kos et al.[6], equations [62] - [67].

Sludge Pumping. (Routine SPUMP,#56) This routine calculates the cost of sludge pumping, using the Black and Veatch cost curves that specify capital, operation and maintenance labor, and operation and maintenance costs as a function of initial firm pumping capacity in gallons per minute. All quality parameters are assumed unchanged by the pumping process.

Wet Oxidation. (Routine WOX,#55) The wet-air oxidation process operates under the principle that organic substances may be oxidized under high pressures at elevated temperature with the sludge in a liquid state by feeding compressed air into the pressure vessel. Thus the process limits its effects to the organic fraction of the input quality parameters, converting a certain portion of these organics to water vapor, CO_2 and nitrogen. Performance characteristics for the low pressure unit were obtained from a paper by G. H. Teletyke.[16] The cost curves were the result of plotting published cost data for a number of existing units.

Grit Cyclone. (Routine CYCL,#54) This routine includes the operations of grit removal and subsequent grit washing and dewatering. It is assumed that the dissolved quality parameters are not affected by the cyclone operation. Solids removal, on the other hand, is specified as an input decision parameter. Performance characteristics and cost data for the system were obtained from data provided by the Wamco Division of Envirotech Corporation.

Biological Nitrification. (Routine BION,#19) The nitrification routine simulates the conversion of ammonia nitrogen to nitrate nitrogen by Nitrosomonas and Nitrobacter. As evident from the program listing, the structure of the routine is exactly the same as that for carbon removal, with the difference that it is the nitrogen rather than the carbon quality parameters that are affected. In fact, the only change in dissolved species is assumed to be in the nitrogen forms. The costs for aerators, blowers, basins, pumps, etc., are assumed to follow the same functions as those used in AERFS, the carbon removal (activated sludge) routine.

The fraction of suspended solids in the overflow stream relative to the influent stream is an input decision parameter. All suspended solid quality parameters are affected equally by this rejection coefficient.

Biological Denitrification. (Routine BIODN,#20) This routine is also based directly on the carbon removal routine (AERFS) for its basic structure. The process is assumed to convert nitrate nitrogen to nitrogen gas in a simulated biological denitrification by Pseudomonas and other facultative anaerobic bacteria. The nitrification and carbon removal routines (BION,AERFS) must precede this routine for proper operation.

The cost of the methanol storage, and flocculators for the denitrification process were obtained from a recent report by Smith[12] who gives the capital cost of the flocculators as:

$$\$ = \text{EXP}\ (9.43 + 0.280\ \ln Q) \quad Q < 10\ \text{MGD} \qquad [11]$$

$$\$ = \text{EXP}\ (7.74 + \ln Q) \quad Q > 10\ \text{MGD} \qquad [12]$$

and for the methanol storage tanks as

$$\$ = \text{EXP}\ (7.86 + 0.430\ \ln Q) \quad Q < 10\ \text{MGD} \qquad [13]$$

$$\$ = \text{EXP}\ (7.38 + 0.632\ \ln Q) \quad Q > 10\ \text{MGD} \qquad [14]$$

As in the case of the nitrification routine, the only change in dissolved species is in the forms of nitrogen present; all other dissolved parameters pass through the routine unaffected. It is assumed that all the methanol added to the process is utilized by the bacteria.

Breakpoint Chlorination. (Routine BKCL2,#21) The breakpoint chlorination model assumes that all ammonia nitrogen will be converted into gaseous forms of nitrogen (N_2, NO, N_2O) by reaction with chlorine. Lime is used to raise the pH to 10.5 to convert NH_4 + to NH_3. The quality parameters affected are ammonium-nitrogen, chloride, calcium, and pH. In this simplified model effects on other constituents are ignored. Design volume is based on a 15-minute detention time in the contact basin. The following cost relationships are used:

Capital cost = (EXP (4.72 + 0.620 ln Q)) * 1000 [15]

Operating and maintenance cost = EXP (2.50 - 0.366 ln Q) [16]

Chemical cost = WPI * EXP (2.50 + 0.303 ln Q) Q < 4 MGD [17]

Chemical cost = WPI * 8.0 Q > 4 MGD [18]

where WPI is the wholesale price index and Q is the flow in MGD. These cost functions are based on an unpublished EPA memorandum by McMichael.[13]

Activated Carbon Adsorption. (Routine CARBON,#29) The activated carbon adsorption column model designs the columns on the basis of a 30-minute detention time, a diameter of 12 ft., and a flow rate of 8 gpm/sq ft. The model does consider the two types of columns in use, packed and expanded beds, but only in relation to the quality parameters. With a packed bed column a rinse flow is needed to remove the accumulated suspended solids. This flow is set at 3 percent of the influent flow, and is assumed to remove all deposited suspended solids. For the packed bed column no rinse stream is needed as less suspended solids are removed and the deposited solids constitute less of a clogging problem. The amounts of dissolved organic carbon and total suspended solids removed are input decision parameters. It is assumed that the removal of SOC and all other suspended solid parameters are governed by the

removal of TSS and that the removal of DOC is caused by adsorption. The approximation is made that DOM, DNBC, and DBOD are removed in proportion to the amount of DOC removed. Nitrate-nitrogen is considered to be 50 percent adsorbed by the carbon. All other dissolved parameters are unaffected. The cost functions, taken from Smith and McMichael,[14] are functions of the flow Q in MGD as follows:

for Q < 10 MGD

Capital cost = 1000000 [Exp (-1.17 + .0623 ln Q)] [19]

Operating and maintenance costs = Exp (3.14-0.517 ln Q) [20]

for Q > 10 MGD

Capital costs = 1000000 [Exp (-1.50 + 0.828 ln Q)] [21]

Operating and maintenance costs = Exp (2.39-0.190 ln Q)

CHAPTER IV

SAMPLE EXECUTIONS

Existing Springfield Treatment Plant

The eight pages of computer printout that follow represent the full output of the program simulation of the existing primary treatment facility in Springfield, Massachusetts, under the simulated addition of 2.25 lb/cap/day of ground refuse to the sewage. The process configuration of the treatment facility under simulation is shown on Figure 5. A discussion of the results of this analysis is to be found in Meier et al.,[5] Chapter V.

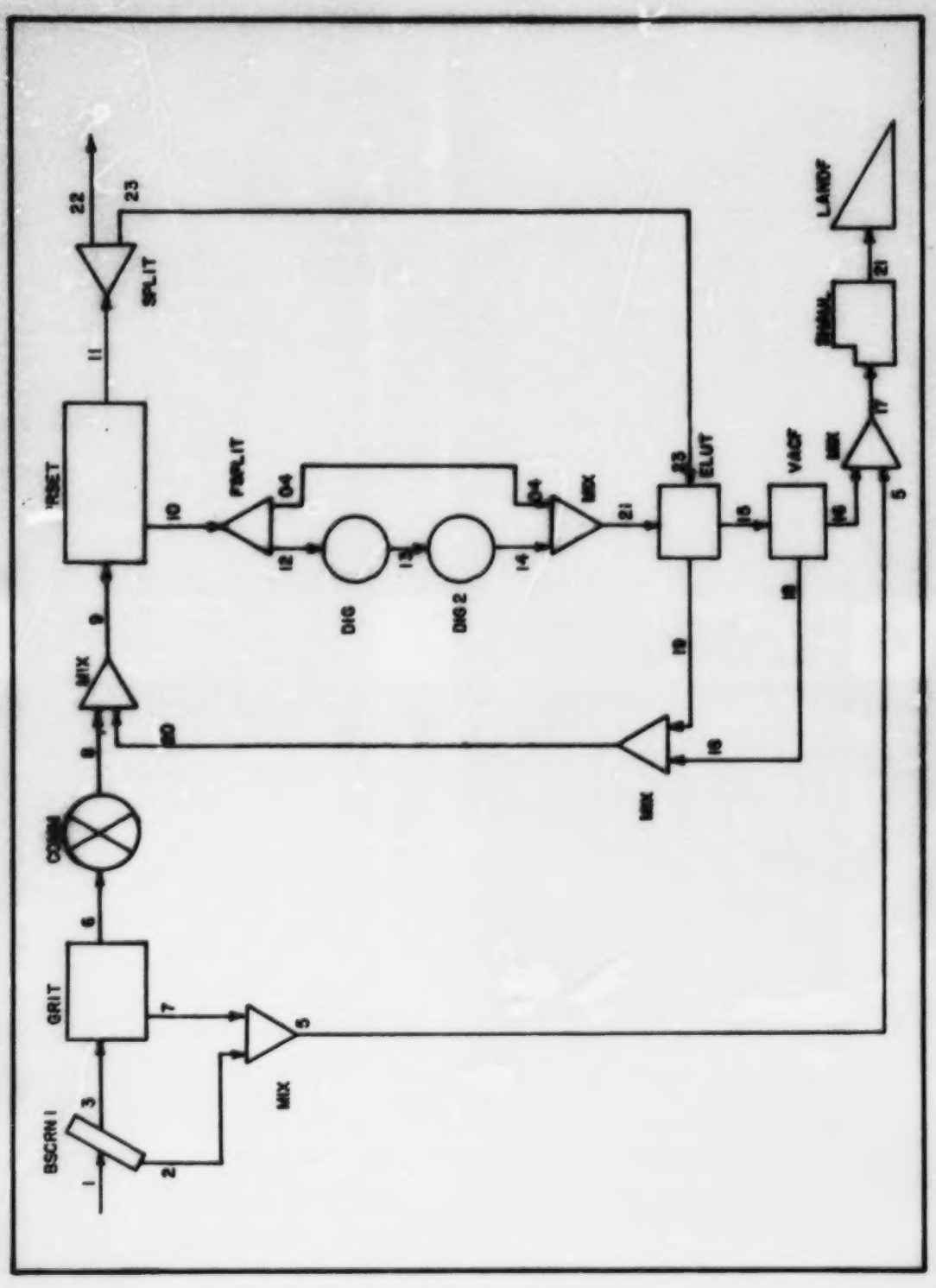


Figure 5: Process Diagram, Existing Springfield Sewage Plant

DIGITAL COMPUTER PROGRAM
FOR
PRELIMINARY DESIGN OF WASTEWATER TREATMENT SYSTEMS

BY
GEORGE G. FISETTE

CURRAN ASSOCIATES INC.
182 MAIN STREET
NORTHAMPTON, MASSACHUSETTS 01060

SPRINGFIELD, EXISTING PLANT, 2.25 LB/CAP/DAY

SYSTEM FLOW SCHEME
INPUT DATA

K	N	PROCESS		IS1	IS2	OS1	OS2	III	MREAD
0	1	3	BSCRN1	1	0	3	2	2	0
0	2	9	GRIT	3	0	6	7	2	0
0	3	11	CUMM	6	0	8	0	2	0
1	0	13	MIX	8	20	9	0	1	0
0	4	15	PRSET	9	0	11	10	0	0
0	2	14	SPLIT	11	0	22	23	0	0
0	9	52	FSPLIT	10	0	12	4	0	1
0	5	37	DIG	12	0	13	0	0	0
0	6	48	DIG2	13	0	14	0	0	0
0	0	13	MIX	14	4	21	0	0	0
0	7	39	ELUT	21	23	15	19	0	0
0	8	40	VACF	15	0	16	18	0	0
1	0	13	MIX	18	19	20	0	1	0
0	0	13	MIX	2	7	5	0	2	0
0	0	13	MIX	5	16	17	0	2	0
0	10	45	LANDF	17	0	24	0	2	0
9	0	0		0	0	0	0	0	0

STREAM CHARACTERISTICS

VOLUME FLOW, MILLIONS OF GALLONS PER DAY
CONCENTRATIONS, MILLIGRAMS/LITER

S 1.

Q	SUC	SUBC	SUN	SOP	SEM	SBOD	VSS
36.000	101.000	60.000	12.000	2.000	873.000	145.000	1643.000
ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS
250.000	73.000	20.000	20.000	8.250	500.000	105.000	2517.000
GSS	NSS	HEAT	GRIT	DOM	ORTOP	AMO	PH
1027.000	1027.000	5289.922	463.000	320.000	7.970	20.780	6.800
CA	MG	NA	K	NH4	CL	HCO3	SO4
75.000	25.000	400.000	20.000	26.720	300.000	100.000	100.000
NO3	PO4	FE	CU	ZN	PB		
23.000	29.920	2.000	0.500	0.200	0.100	0.0	0.0

S 2.

Q	SUC	SUBC	SUN	SOP	SEM	SBOD	VSS
0.001	88841.250	40895.801	8179.150	1363.193	0.0	98831.500	699999.750
ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS
250.000	73.000	20.000	20.000	8.250	500.000	105.000	699999.750
GSS	NSS	HEAT	GRIT	DOM	ORTOP	AMO	PH
699999.750	0.0	23.595	0.0	320.000	7.970	20.780	6.800
CA	MG	NA	K	NH4	CL	HCO3	SO4
75.000	25.000	400.000	20.000	26.720	300.000	100.000	100.000
NO3	PO4	FE	CU	ZN	PB		
23.000	29.920	2.000	0.500	0.200	0.100	0.0	0.0

S 3.

Q	SUC	SUBC	SUN	SOP	SEM	SBOD	VSS
35.999	93.991	59.401	11.880	1.980	873.000	143.552	1632.745
ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS
250.000	73.000	20.000	20.000	8.250	500.000	105.000	2506.745
GSS	NSS	HEAT	GRIT	DOM	ORTOP	AMO	PH
1016.745	1027.000	5266.324	463.000	320.000	7.970	20.780	6.800
CA	MG	NA	K	NH4	CL	HCO3	SO4
75.000	25.000	400.000	20.000	26.720	300.000	100.000	100.000
NO3	PO4	FE	CU	ZN	PB		
23.000	29.920	2.000	0.500	0.200	0.100	0.0	0.0

S 4.

Q	SUC	SUBC	SUN	SOP	SEM	SBOD	VSS
0.223	3902.708	2334.516	470.829	76.472	21268.574	5687.414	90291.438
ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS
250.967	73.102	20.000	20.293	8.312	500.000	105.293	111608.438
GSS	NSS	HEAT	GRIT	DOM	ORTOP	AMO	PH
64053.234	46153.012	0.223	1402.295	320.000	7.970	20.780	6.800
CA	MG	NA	K	NH4	CL	HCO3	SO4
75.000	25.000	400.000	20.000	26.720	300.000	100.000	100.000
NO3	PO4	FE	CU	ZN	PB		
23.000	29.920	2.000	0.500	0.200	0.100	0.0	0.0

S 5.

Q	SUC	SUBC	SUN	SOP	SEM	SBOD	VSS
0.015	46319.773	27210.691	5503.336	917.223	1074854.000	66498.625	741340.500
ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS
250.000	73.000	20.000	20.000	8.250	500.000	105.000	1816195.000
GSS	NSS	HEAT	GRIT	DOM	ORTOP	AMO	PH
562198.000	179142.375	880.686	1074854.000	320.000	7.970	20.780	6.800
CA	MG	NA	K	NH4	CL	HCO3	SO4
75.000	25.000	400.000	20.000	26.720	300.000	100.000	100.000
NO3	PO4	FE	CU	ZN	PB		
23.000	29.920	2.000	0.500	0.200	0.100	0.0	0.0

S 6.	Q	SUC	SNBC	SUN	SOP	SFM	SBOD	VSS
	35.985	81.830	48.612	9.722	1.620	427.533	117.479	1336.188
	ALK	DUC	UNBC	DN	DP	DFM	DBOD	TSS
	250.000	73.000	20.000	20.000	8.250	500.000	105.000	1763.721
	GSS	NSS	HEAT	GRIT	DUM	ORTOP	AMO	PH
	794.245	953.109	4029.230	17.369	320.000	7.970	20.780	6.800
	CA	MG	NA	K	NH4	CL	HCO3	SO4
	75.000	25.000	400.000	20.000	26.720	300.000	100.000	100.000
	NO3	PO4	FE	CU	ZN	PB		
	23.000	29.420	2.000	0.500	0.200	0.100	0.0	0.0
S 7.	Q	SUC	SNBC	SUN	SOP	SFM	SBOD	VSS
	0.018	45493.555	27025.807	5405.172	900.862	114286.000	65312.527	742857.000
	ALK	DUC	UNBC	DN	DP	DFM	DBOD	TSS
	250.000	73.000	20.000	20.000	8.250	500.000	105.000	1857143.000
	GSS	NSS	HEAT	GRIT	DUM	ORTOP	AMO	PH
	557142.625	185714.313	037.392	114286.000	320.000	7.970	20.780	6.800
	CA	MG	NA	K	NH4	CL	HCO3	SO4
	75.000	25.000	400.000	20.000	26.720	300.000	100.000	100.000
	NO3	PO4	FE	CU	ZN	PB		
	23.000	29.420	2.000	0.500	0.200	0.100	0.0	0.0
S 8.	Q	SUC	SNBC	SUN	SOP	SFM	SBOD	VSS
	35.985	81.830	48.612	9.722	1.620	427.533	117.479	1336.188
	ALK	DUC	UNBC	DN	DP	DFM	DBOD	TSS
	250.000	73.000	20.000	20.000	8.250	500.000	105.000	1763.721
	GSS	NSS	HEAT	GRIT	DUM	ORTOP	AMO	PH
	794.245	953.109	4029.230	17.369	320.000	7.970	20.780	6.800
	CA	MG	NA	K	NH4	CL	HCO3	SO4
	75.000	25.000	400.000	20.000	26.720	300.000	100.000	100.000
	NO3	PO4	FE	CU	ZN	PB		
	23.000	29.420	2.000	0.500	0.200	0.100	0.0	0.0
S 9.	Q	SUC	SNBC	SUN	SOP	SFM	SBOD	VSS
	37.225	79.255	47.090	9.417	1.569	414.153	113.748	1293.403
	ALK	DUC	UNBC	DN	DP	DFM	DBOD	TSS
	250.007	73.105	20.000	20.243	8.312	500.000	105.293	1707.559
	GSS	NSS	HEAT	GRIT	DUM	ORTOP	AMO	PH
	768.638	923.060	3617.324	16.828	320.000	7.970	20.780	6.800
	CA	MG	NA	K	NH4	CL	HCO3	SO4
	75.000	25.000	400.000	20.000	26.720	300.000	100.000	100.000
	NO3	PO4	FE	CU	ZN	PB		
	23.000	29.420	2.000	0.500	0.200	0.100	0.0	0.0
S10.	Q	SUC	SNHC	SON	SOP	SFM	SBOD	VSS
	0.447	3962.768	2354.516	470.829	78.472	21268.574	5687.414	90291.438
	ALK	DUC	UNBC	DN	DP	DFM	DBOD	TSS
	250.007	73.105	20.000	20.243	8.312	500.000	105.293	111608.438
	GSS	NSS	HEAT	GRIT	DUM	ORTOP	AMO	PH
	64053.234	46153.012	2910.531	1402.295	320.000	7.970	20.780	6.800
	CA	MG	NA	K	NH4	CL	HCO3	SO4
	75.000	25.000	400.000	20.000	26.720	300.000	100.000	100.000
	NO3	PO4	FE	CU	ZN	PB		
	23.000	29.420	2.000	0.500	0.200	0.100	0.0	0.0
S11.	Q	SUC	SNHC	SON	SOP	SFM	SBOD	VSS
	36.778	32.087	19.065	3.812	0.635	160.861	46.052	212.455
	ALK	DUC	UNBC	DN	DP	DFM	DBOD	TSS
	250.867	73.165	20.000	20.243	8.312	500.000	105.293	373.708

GSS	NSS	HEAT	GRIT	DOM	ORTOP	AMO	PH	
0.0	373.708	706.792	0.0	320.000	7.970	20.780	6.800	
CA	MG	NA	K	NH4	CL	HCO3	SO4	
75.000	25.000	400.000	20.000	26.720	300.000	100.000	100.000	
NO3	PO4	FE	CU	ZN	PB			
23.000	29.420	2.000	0.500	0.200	0.100	0.0	0.0	

S12.								
Q	SOC	SNBC	SON	SOP	SEM	SBOD	VSS	
0.223	3962.760	2334.516	470.829	78.472	21268.574	5687.414	90291.438	
ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS	
230.867	73.103	20.000	20.243	8.312	500.000	105.293	111608.438	
GSS	NSS	HEAT	GRIT	DOM	ORTOP	AMO	PH	
64053.234	46153.012	0.223	1402.295	320.000	7.970	20.780	6.800	
CA	MG	NA	K	NH4	CL	HCO3	SO4	
75.000	25.000	400.000	20.000	26.720	300.000	100.000	100.000	
NO3	PO4	FE	CU	ZN	PB			
23.000	29.420	2.000	0.500	0.200	0.100	0.0	0.0	

S13.								
Q	SOC	SNBC	SON	SOP	SEM	SBOD	VSS	
0.223	2699.624	2334.516	330.689	55.115	19866.277	645.352	5784.566	
ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS	
576.661	133.036	20.000	111.436	31.669	500.000	215.117	27693.676	
GSS	NSS	HEAT	GRIT	DOM	ORTOP	AMO	PH	
640.532	25693.844	301.098	1402.295	320.000	7.970	20.780	6.800	
CA	MG	NA	K	NH4	CL	HCO3	SO4	
75.000	25.000	400.000	20.000	26.720	300.000	100.000	100.000	
NO3	PO4	FE	CU	ZN	PB			
23.000	29.420	2.000	0.500	0.200	0.100	0.0	0.0	

S14.								
Q	SOC	SNBC	SON	SOP	SEM	SBOD	VSS	
0.100	4874.078	4250.946	597.048	99.508	38993.551	1165.161	11871.563	
ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS	
576.661	133.036	20.000	111.436	31.669	500.000	215.117	50865.113	
GSS	NSS	HEAT	GRIT	DOM	ORTOP	AMO	PH	
1427.728	46311.719	297.550	3125.673	320.000	7.970	20.780	6.800	
CA	MG	NA	K	NH4	CL	HCO3	SO4	
75.000	25.000	400.000	20.000	26.720	300.000	100.000	100.000	
NO3	PO4	FE	CU	ZN	PB			
23.000	29.420	2.000	0.500	0.200	0.100	0.0	0.0	

S15.								
Q	SOC	SNBC	SON	SOP	SEM	SBOD	VSS	
0.380	2744.717	1402.131	329.701	54.950	17301.055	2771.802	42677.348	
ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS	
276.045	77.955	20.000	27.296	10.121	500.000	113.796	59999.996	
GSS	NSS	HEAT	GRIT	DOM	ORTOP	AMO	PH	
28875.059	29873.246	1332.138	1251.784	320.000	7.970	20.780	6.800	
CA	MG	NA	K	NH4	CL	HCO3	SO4	
75.000	25.000	400.000	20.000	26.720	300.000	100.000	100.000	
NO3	PO4	FE	CU	ZN	PB			
23.000	29.420	2.000	0.500	0.200	0.100	0.0	0.0	

S16.								
Q	SOC	SNBC	SON	SOP	SEM	SBOD	VSS	
0.055	19054.805	13203.313	2288.913	381.486	120110.500	19242.902	296282.375	
ALK	DOC	DNBC	DN	DP	DFM	DBOD	TSS	
276.045	77.955	20.000	27.296	10.121	500.000	113.796	416562.813	
GSS	NSS	HEAT	GRIT	DOM	ORTOP	AMO	PH	
200401.625	207391.438	1328.335	8690.363	320.000	7.970	20.780	6.800	
CA	MG	NA	K	NH4	CL	HCO3	SO4	
75.000	25.000	400.000	20.000	26.720	300.000	100.000	100.000	
NO3	PO4	FE	CU	ZN	PB			
23.000	29.420	2.000	0.500	0.200	0.100	0.0	0.0	

S17.	Q	SUC	SnBC	SON	SOP	SFM	SBOD	VSS
	0.070	24935.965	16276.559	2978.734	496.456	325000.063	29384.063	391792.625
	ALK	DUC	DNBC	DN	DP	DFM	DBOD	TSS
	270.456	76.892	20.000	25.730	4.719	500.000	111.908	716910.688
	GSS	NSS	HEAT	GRIT	DOM	ORTOP	AMO	PH
	278090.875	201329.125	1989.021	237490.875	320.000	7.970	20.780	6.800
	CA	MG	NA	K	NH4	CL	HCO3	SO4
	75.000	25.000	400.000	20.000	26.720	300.000	100.000	100.000
	NO3	PO4	FE	CU	ZN	PB		
	23.000	29.420	2.000	0.500	0.200	0.100	0.0	0.0

S18.	Q	SUC	SnBC	SON	SOP	SFM	SBOD	VSS
	0.326	9.149	6.340	1.099	0.183	57.670	9.239	142.258
	ALK	DUC	DNBC	DN	DP	DFM	DBOD	TSS
	276.045	77.955	20.000	27.296	10.121	500.000	113.796	200.000
	GSS	NSS	HEAT	GRIT	DOM	ORTOP	AMO	PH
	96.250	99.577	3.803	4.173	320.000	7.970	20.780	6.800
	CA	MG	NA	K	NH4	CL	HCO3	SO4
	75.000	25.000	400.000	20.000	26.720	300.000	100.000	100.000
	NO3	PO4	FE	CU	ZN	PB		
	23.000	29.420	2.000	0.500	0.200	0.100	0.0	0.0

S19.	Q	SUC	SnBC	SON	SOP	SFM	SBOD	VSS
	0.914	2.864	1.701	0.340	0.057	14.356	4.110	18.961
	ALK	DUC	DNBC	DN	DP	DFM	DBOD	TSS
	276.045	77.955	20.000	27.296	10.121	500.000	113.796	33.352
	GSS	NSS	HEAT	GRIT	DOM	ORTOP	AMO	PH
	0.0	33.352	-1015.711	0.0	320.000	7.970	20.780	6.800
	CA	MG	NA	K	NH4	CL	HCO3	SO4
	75.000	25.000	400.000	20.000	26.720	300.000	100.000	100.000
	NO3	PO4	FE	CU	ZN	PB		
	23.000	29.420	2.000	0.500	0.200	0.100	0.0	0.0

S20.	Q	SUC	SnBC	SON	SOP	SFM	SBOD	VSS
	1.240	4.313	2.920	0.540	0.090	25.736	5.458	51.356
	ALK	DUC	DNBC	DN	DP	DFM	DBOD	TSS
	276.045	77.955	20.000	27.296	10.121	500.000	113.796	77.137
	GSS	NSS	HEAT	GRIT	DOM	ORTOP	AMO	PH
	25.289	50.752	-1011.907	1.096	320.000	7.970	20.780	6.800
	CA	MG	NA	K	NH4	CL	HCO3	SO4
	75.000	25.000	400.000	20.000	26.720	300.000	100.000	100.000
	NO3	PO4	FE	CU	ZN	PB		
	23.000	29.420	2.000	0.500	0.200	0.100	0.0	0.0

S21.	Q	SUC	SnBC	SON	SOP	SFM	SBOD	VSS
	0.324	4244.996	2941.848	509.918	84.986	26757.926	4286.887	66005.063
	ALK	DUC	DNBC	DN	DP	DFM	DBOD	TSS
	351.578	92.320	20.000	48.453	15.546	500.000	139.305	92796.375
	GSS	NSS	HEAT	GRIT	DOM	ORTOP	AMO	PH
	44658.352	46202.156	297.773	1936.018	320.000	7.970	20.780	6.800
	CA	MG	NA	K	NH4	CL	HCO3	SO4
	75.000	25.000	400.000	20.000	26.720	300.000	100.000	100.000
	NO3	PO4	FE	CU	ZN	PB		
	23.000	29.420	2.000	0.500	0.200	0.100	0.0	0.0

S22.	Q	SUC	SnBC	SON	SOP	SFM	SBOD	VSS
	35.807	32.087	19.065	3.812	0.635	160.861	46.052	212.455
	ALK	DUC	DNBC	DN	DP	DFM	DBOD	TSS
	250.867	13.162	20.000	20.243	8.312	500.000	105.293	373.708

	GSS	NSS	HEAT	GRIT	DOM	ORTOP	AMO	PH	
	0.0	373.70d	odd.15d	0.0	320.000	7.970	20.780	6.800	
	CA	MG	NA	K	NH4	CL	HCO3	SO4	
	75.000	25.000	400.000	20.000	26.720	300.000	100.000	100.000	
	NO3	PO4	FE	CU	ZN	PB			
	23.000	24.42U	2.000	0.500	0.200	0.100	0.0	0.0	
S23.	D	SUC	SNBC	SUN	SOP	SFM	SBOD	VSS	
	0.971	32.087	19.065	3.812	0.635	160.861	46.052	212.455	
	ALK	DUC	DNBC	DN	DP	DFM	DBOD	TSS	
	250.867	73.165	20.000	20.263	8.312	500.000	105.293	371.708	
	GSS	NSS	HEAT	GRIT	DOM	ORTOP	AMO	PH	
	0.0	373.70d	1d.654	0.0	320.000	7.970	20.780	6.800	
	CA	MG	NA	K	NH4	CL	HCO3	SO4	
	75.000	25.000	400.000	20.000	26.720	300.000	100.000	100.000	
	NO3	PO4	FE	CU	ZN	PB			
	23.000	24.42U	2.000	0.500	0.200	0.100	0.0	0.0	
S24.	D	SUC	SNBC	SUN	SOP	SFM	SBOD	VSS	
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	ALK	DUC	DNBC	DN	DP	DFM	DBOD	TSS	
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	GSS	NSS	HEAT	GRIT	DOM	ORTOP	AMO	PH	
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	CA	MG	NA	K	NH4	CL	HCO3	SO4	
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
	NO3	PO4	FE	CU	ZN	PB			
	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	

PROCESS CHARACTERISTICS

CCOST = CAPITAL COST, DOLLARS
CUSTO = OPERATING + MAINTENANCE COST, CENTS/1000 GAL.
ACOST = AMORIZATION COST, CENTS/1000 GAL.
TCOST = TOTAL TREATMENT COST, CENTS/1000 GAL.

TOTAL PLANT COST

TOTAL CAPITAL COST = 8658844. DOLLARS

TOTAL ANNUITIZATION COST = 5.155 CENTS/1000 GAL.

TOTAL O & M COST = 4.801 CENTS/1000 GAL.

TOTAL TREATMENT COST = 9.956 CENTS/1000 GAL.

CCI	WPI	RI	YRS	OHR	PCT	QA	CCINT	XLAB
176.100	120.000	0.000	25.0	3.50	0.150	1000.	0.06	1.00

RATIO	TCAP	YARD	TCC	XLAND	ENG	SUBT1	FISC	SUBT2	XINT
1.336	6481480.	907407.	7388890.	38896.	583294.	8011078.	45091.	8056167.	602682.

ACRE	AF
38.90	0.07823

		CCOST	COSTO	ACOST	TCOST
ADMINISTRATIVE AND LABORATORY		374472.	0.281	0.223	0.504
GARAGE AND SHOP		116189.	0.0	0.069	0.069
LABORATORY OPERATION	XLAB 1.0	0.	0.214	0.0	0.214
YARDWORK OPERATION		0.	0.196	0.0	0.196

P 1	BAR SCREEN NO.1	FGSSR	SOLIDS	VELH2O	ABS	SCREEN				
		0.100E-01	70.0	2.00	27.9	20.9				
						CCOST	COSTO	ACOST	TCOST	ECF
					PURCHASE	20094.	0.001	0.012	0.013	1.50
					INSTALL	5023.				
P 2	GRIT CHAMBER	FLRWAT	FSHGAT	MOIST	ORGAN	DENSIT	FGSS	FTHR	FTHG	
	AERATED	0.95	0.25	0.35	0.40	80.00	0.75	178.68	119.12	
						CCOST	COSTO	ACOST	TCOST	COSTO ECF
						13816.	0.001	0.008	0.010	1.00
P 3	COMMINUTOR	HRDY				CCOST	COSTO	ACOST	TCOST	ECF
		26.00				48231.	0.002	0.029	0.031	1.00
P 4	PRIMARY	FRPS	UNPS	HPWK	GPS	APS	PGPM	FGSSR	FGRITR	
	SETTLER	0.60	50.0	14.0	868.4	42.866	4667.	1.00	1.00	
						CCOST	COSTO	ACOST	TCOST	ECF
					SETTLER	714353.	0.160	0.425	0.585	1.00
					SLUDGE PUMPS	543879.	0.334	0.324	0.658	1.20
P 5	ANAEROBIC	TD	TWIG	C1DIG	C2DIG	VDIG	CH4	CO2		
	DIGESTER	15.0	86.0	0.234	1154.	448.	43961.	23087.		
						CCOST	COSTO	ACOST	TCOST	ECF
						1193172.	0.210	0.710	0.920	1.00
P 6	SECOND STAGE	TRR	TSS	TD	VDIG		CCOST	COSTO	ACOST	TCOST	ECF
	ANAEROBIC DIGESTION	0.81	50000.	5.0	149.		478344.	0.096	0.285	0.381	1.00
P 7	ELUTRIATION	ERR	TSS	WRF	GE	GES	AE			
		0.76	60000.	3.0	800.0	9.0	41684.			
						CCOST	COSTO	ACOST	TCOST	ECF
						1779622.	0.0	1.059	1.059	1.50
P 8	VACUUM	VFL	HPWK	TSS	IVACF	FECL3	WP	AVF		
	FILTER	4.90	105.	200.	1.00	5.42	70.6	4728.6		
						CCOST	COSTO	ACOST	TCOST	ECF
						3371651.	3.306	2.007	5.313	1.00

ITER# 6

Planned Springfield Treatment Plant

The six pages of computer print-out following Figure 6 represent the output of the simulation of the planned Springfield treatment plant, currently under construction. The process configuration is shown on Figure 6. The first page of output is a listing of the control cards needed for execution on an IBM System 360/30 DOS; the ASSGN, DLBL and EXTENT statements are necessary for the direct access features of the program (see Chapter II).

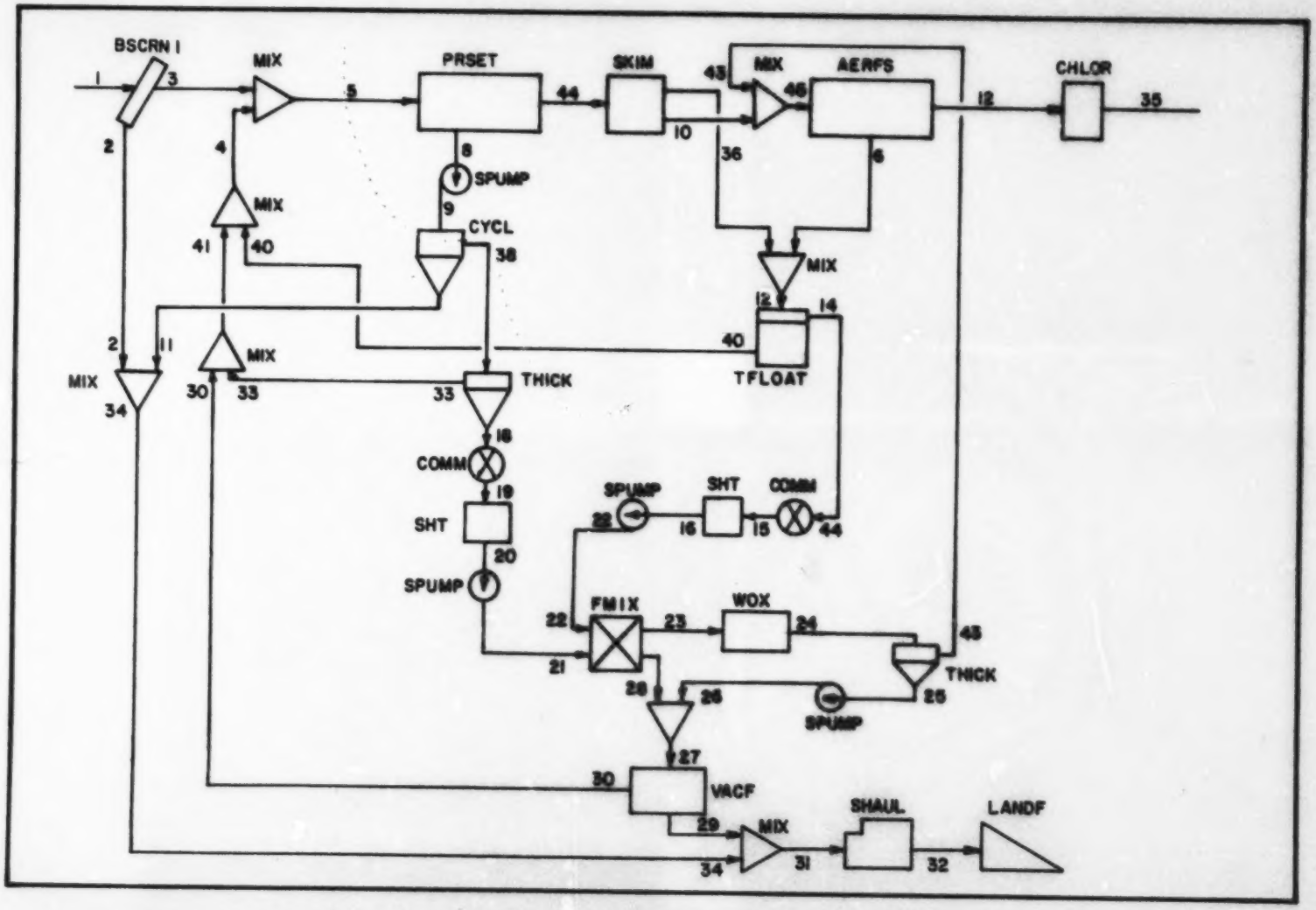


Figure 6: Process Diagram, Planned Springfield Sewage Treatment Plant

```
// OPTION LOG,LINK,NODUMP,NOLISTX
// ASSGN SYSSLB,X'133@'
// DLBL IJSYSSL,'MOS R26 PVT CUR SOURCE',99/365,SD
// EXTENT SYSSLB,PVTCUR,1,000,1220,1000
// ASSGN SYSRLB,X'133@'
// DLBL IJSYSRL,'MOS R26 PVT CUR RELOC',99/365,SD
// EXTENT SYSRLB,PVTCUR,1,000,1001,1200
// ASSGN SYS002,X'133@'
// DLBL IJSYS02,'AMATX AND ARFD STORAGE AREA',99/365,SD
// EXTENT SYS002,PVTCUR,1,,2241,3
// ASSGN SYS003,X'133@'
// DLBL IJSYS03,'PROCESS CARDS STORAGE AREA',99/365,SD
// EXTENT SYS003,PVTCUR,1,,2240,5
// ASSGN SYS004,X'133@'
// DLBL IJSYS04,'CUSTO STORAGE AREA',99/365,SD
// EXTENT SYS004,PVTCUR,1,,2251,3
// ASSGN SYS005,X'133@'
// DLBL IJSYS05,'TCOST STORAGE AREA',99/365,SD
// EXTENT SYS005,PVTCUR,1,,2254,3
// ASSGN SYS006,X'133@'
// DLBL IJSYS06,'ACOST STORAGE AREA',99/365,SD
// EXTENT SYS006,PVTCUR,1,,2257,3
// ASSGN SYS007,X'133@'
// DLBL IJSYS07,'CCOST STORAGE AREA',99/365,SD
// EXTENT SYS007,PVTCUR,1,,2200,3
// ASSGN SYS008,X'133@'
// DLBL IJSYS08,'DMATX STORAGE AREA',99/365,SD
// EXTENT SYS008,PVTCUR,1,,2203,3
// ASSGN SYS009,X'133@'
// DLBL IJSYS09,'DMATX STORAGE AREA',99/365,SD
// EXTENT SYS009,PVTCUR,1,,2206,3
// ASSGN SYS010,X'133@'
// DLBL IJSYS10,'TMATX STORAGE AREA',99/365,SD
// EXTENT SYS010,PVTCUR,1,,2269,10
// ASSGN SYS011,X'133@'
// DLBL IJSYS11,'SMATX STORAGE AREA',99/365,SD
// EXTENT SYS011,PVTCUR,1,,2279,10
// EXEC CURIMAIN
```

DIGITAL COMPUTER PROGRAM
FOR
PRELIMINARY DESIGN OF WASTEWATER TREATMENT SYSTEMS

BY
GEORGE R. FISETTE

CURRAN ASSOCIATES INC.
182 MAIN STREET
NORTHAMPTON, MASSACHUSETTS 01060

PLANNED SPRINGFIELD SEWAGE TREATMENT PLANT, SEWAGE

SYSTEM FLOW SCHEME
INPUT DATA

K	N	PROCESS	IS1	IS2	OS1	OS2	III	NREAD
0	1	3 DSCRN	1	0	3	2	2	0
1	0	13 MIX	3	4	5	0	1	0
0	2	15 PRSET	5	0	44	8	0	0
0	3	50 SKIM	44	0	10	36	0	0
0	0	13 MIX	10	43	45	0	0	0
0	4	10 AERFS	45	0	13	6	0	0
0	0	13 MIX	36	6	12	0	0	0
0	5	35 TFLOAT	12	0	14	40	0	0
0	6	50 SPUMP	8	0	9	0	0	0
0	7	54 CYCL	9	0	38	11	0	0
0	8	34 THICK	38	0	18	33	0	0
0	9	11 COMM	18	0	19	0	0	0
0	10	30 SHT	19	0	20	0	0	1
0	11	50 SPUMP	20	0	21	0	0	0
0	12	11 COMM	14	0	15	0	0	0
0	13	30 SHT	15	0	16	0	0	1
0	14	50 SPUMP	16	0	22	0	0	0
0	15	57 FMIX	21	22	23	28	0	0
0	16	55 MUX	23	0	24	0	0	0
0	17	34	24	0	25	43	0	1
0	18	50 SPUMP	25	0	26	0	0	0
0	0	13 MIX	26	28	27	0	0	0
0	19	40 VACF	27	0	29	30	0	0
0	0	13 MIX	30	33	41	0	0	0
1	0	13 MIX	41	40	4	0	1	0
0	0	13 MIX	2	11	34	0	2	0
0	0	13 MIX	34	29	31	0	2	0
0	20	53 SHAUL	31	0	32	0	2	0
0	21	45 LANDF	32	0	43	0	2	0
0	22	33 CHLOR	13	0	35	0	2	0
9	0	0	0	0	0	0	0	0

PROCESS 3.ITERATION 1
STREAM 3 MGD 64.400 TSS 164.0

STREAM 2 MGD 0.0 TSS 0.0

PROCESS 13.ITERATION 1
STREAM 5 MGD 64.400 TSS 164.0

PROCESS 15.ITERATION 1
STREAM 8 MGD 0.773 TSS 8563.3

PROCESS CHARACTERISTICS

CCOST = CAPITAL COST, DOLLARS
COSTO = OPERATING + MAINTENANCE COST, CENTS/1000 GAL.
ACOST = AMORIZATION COST, CENTS/1000 GAL.
TCOST = TOTAL TREATMENT COST, CENTS/1000 GAL.

TOTAL PLANT COST

TOTAL CAPITAL COST = 24320912. DOLLARS

TOTAL AMORTIZATION COST = 8.094 CENTS/1000 GAL.

TOTAL O & M COST = 5.806 CENTS/1000 GAL.

TOTAL TREATMENT COST = 13.900 CENTS/1000 GAL.

CCI	WPI	RI	YRS	DHR	PCT	DA	CCINT	XLAB
176.100	120.000	0.000	25.0	3.50	0.150	1000.	0.06	1.00

RATIO	TCAP	YARD	TCC	XLAND	ENG	SUBT1	FISC	SUBT2	XINT
1.332	18255200.	2555728.	20810944.	54716.	1427072.	22292704.	72385.	22365104.	1955886.

ACRE	AF
54.72	0.07023

		CCOST	COSTO	ACOST	TCOST
ADMINISTRATIVE AND LABORATORY		522698.	0.236	0.174	0.410
GARAGE AND SHOP		174115.	0.0	0.058	0.058
LABORATORY OPERATION	XLAB 1.0	0.	0.166	0.0	0.166
YARDWORK OPERATION		0.	0.180	0.0	0.180

P 1 BAR SCREEN NO.1

FGSSR	SOLIDS	VELH2O	AHS	SCREEN
0.10QE-01	70.0	2.00	49.8	37.4

	CCOST	COSTO	ACOST	TCOST	ECF
PURCHASE	25892.	0.301	0.009	0.009	1.50
INSTALL	6473.				

P 2 PRIMARY SETTLER

FRPS	URPS	HPWK	GPS	APS	PGPM	FGSSR	FGRITR
0.60	50.0	100.0	808.4	305.148	552.	1.00	1.00

	CCOST	COSTO	ACOST	TCOST	ECF
SETTLER	3920910.	0.131	1.305	1.436	4.00
SLUDGE PUMPS	155562.	0.071	0.052	0.123	1.00

P 3 SKIMMER REM

WF	FRACVS
1.00	0.20 0.70

P 4 AERATOR-FINAL SETTLER

						CCOST	COSTO	ACOST	TCOST	
						0.0	0.0	0.0	0.0	
BOD	MLSS	DEGF	CAER20	DO	AEFF20	URSS	GSS	HEAD		
20.0	2000.	20.00	1.00	1.00	0.05	3.00	667.00	30.00		
BOD2	DOSAT	XMSS	AFS	CAER	CEOP	VAER	VNIT	MLASS	MLBSS	
80.4	10.8	0.0116	504.69	1.00	0.125	14.430	17.831	268.	805.	
MLNBSS	MLDSS	MLISS	FUDD	RTURN	CNIT	ARCFD	HSIZE	CFPGL	AEFF	
402.	0.	402.	29.3	0.498	0.32113369743.		32498.	0.20	0.05	

	CCOST	COSTO	ACOST	TCOST	ECF
AERATOR	2644655.	0.0	0.880	0.880	3.50
BLOWER	1186172.	0.833	0.395	1.228	3.50
SLUDGE PUMPS	1196245.	0.214	0.398	0.612	3.50
FINAL SETTLER	6150369.	0.198	2.047	2.244	3.50

P 5 FLOTATION THICKENING

THK	TSS	GTH	GSTH	HPWK	DPOLY	CPOLY
3.85	40000.	540.00	9.00	100.00	10.00	0.45
ATHM	XN	ATHNL			CCOST	COSTO	ACOST	TCOST	ECF
1048.1	0.0	988d.5			1500554.	0.710	0.499	1.209	1.00

P 6 SLUDGE PUMP

ECF	GPM
552.00	0.0

	CCOST	COSTO	ACOST	TCOST
	180023.6	0.07	0.06	0.13

P 7 GRIT CYCLONE

FGRIT	WF	VSSF	UENS	WGSS	ECF
0.85	0.01	0.22	0.10	0.0	0.0

	CCOST	COSTO	ACOST	TCOST
	94904.9	0.01	0.03	0.04

P 8 GRAVITY

THK	TSS	GTH	GSTH	ATHM
				WAT

	THICKENER	0.95	120000.0	293.0	11.0	7766.8	0.00				
								CCOST	COSTO	ACOST	TCOST	ECF
								19e454.	0.023	0.065	0.088	1.50
P 9	COMMINUTOR	HRDY						CCOST	COSTO	ACOST	TCOST	ECF
		0.0						0.	0.0	0.0	0.0	1.00
P10	SLUDGE HOLDING	TD	VOLT					CCOST	COSTO	ACOST	TCOST	ECF
	TANK	1.5	10.9					121042.	0.031	0.040	0.071	1.00
P11	SLUDGE PUMP	ECF	GPM									
		37.59	0.0									
								CCOST	COSTO	ACOST	TCOST	
								47709.9	0.02	0.02	0.04	
P12	COMMINUTOR	HRDY						CCOST	COSTO	ACOST	TCOST	ECF
		2e.00						4676.	0.000	0.002	0.002	1.00
P13	SLUDGE HOLDING	TD	VOLT					CCOST	COSTO	ACOST	TCOST	ECF
	TANK	1.5	29.3					230246.	0.053	0.077	0.130	1.00
P14	SLUDGE PUMP	ECF	GPM									
		101.35	0.0									
								CCOST	COSTO	ACOST	TCOST	
								70915.1	0.03	0.02	0.05	
P16	WET OXIDATION	FSS	FVSS	FCC	FONC	FSBOD	FDBOD	XIAMN	ALKO	PHRAT	ECF	
		0.22	0.30	0.25	0.80	0.90	4.00	1.80	0.80	0.80	1.00	
								CCOST	COSTO	ACOST	TCOST	
								3167376.0	0.03	1.05	1.08	
P17	GRAVITY	TKR	TSS	GTH	GSTH	ATHM	HRT					
	THICKENER	0.95	110000.0	0.0	0.0	3928.0	0.00					
								CCOST	COSTO	ACOST	TCOST	ECF
								127610.	0.019	0.042	0.062	1.00
P18	SLUDGE PUMP	ECF	GPM									
		41.33	0.0									
								CCOST	COSTO	ACOST	TCOST	
								49509.9	0.02	0.02	0.04	
P19	VACUUM	VFL	HRWK	TSS	IVACF	FECL3	WP	AVF				
	FILTER	10.50	10e.	.20e.	1.00	2.96	65.1	1971.3				
								CCOST	COSTO	ACOST	TCOST	ECF
								1656140.	1.483	0.551	2.035	2.50
P20	SLUDGE HAUL	TCAP	DIST	SPEED	CPPU	RHOUR						
		40.00	10.00	25.00	30.00	15.00						
								CCOST	COSTO	ACOST	TCOST	
								0.0	0.26	0.0	0.26	

P21 LANDFILL

CLEAN	DEPTH	DEPTH	YEAR
1000.0	0.00	3.00	0.0

P22 CHLORINATION

DCL2	TCA2
10.0	30.0

	CCOST	COSTO	ACOST	TCOST	
	0.0	0.35	0.0	0.35	
	CCOST	COSTO	ACOST	TCOST	ECF
FEED SYSTEM	396651.	0.066	0.129	0.795	1.50
CONTACT BASIN	502112.	0.0	0.167	0.167	1.50

ITEM # 7

Recommended Springfield Treatment Plant

The five pages of computer print-out that follow Figure 7 are sample output for the simulation of the treatment facility that would be recommended for Springfield if 2.25 lb/cap/day of ground residential refuse were added to the sewage. The process configuration, as shown on Figure 7, is discussed and justified at some length in Chapter V of the Phase II report.[15]

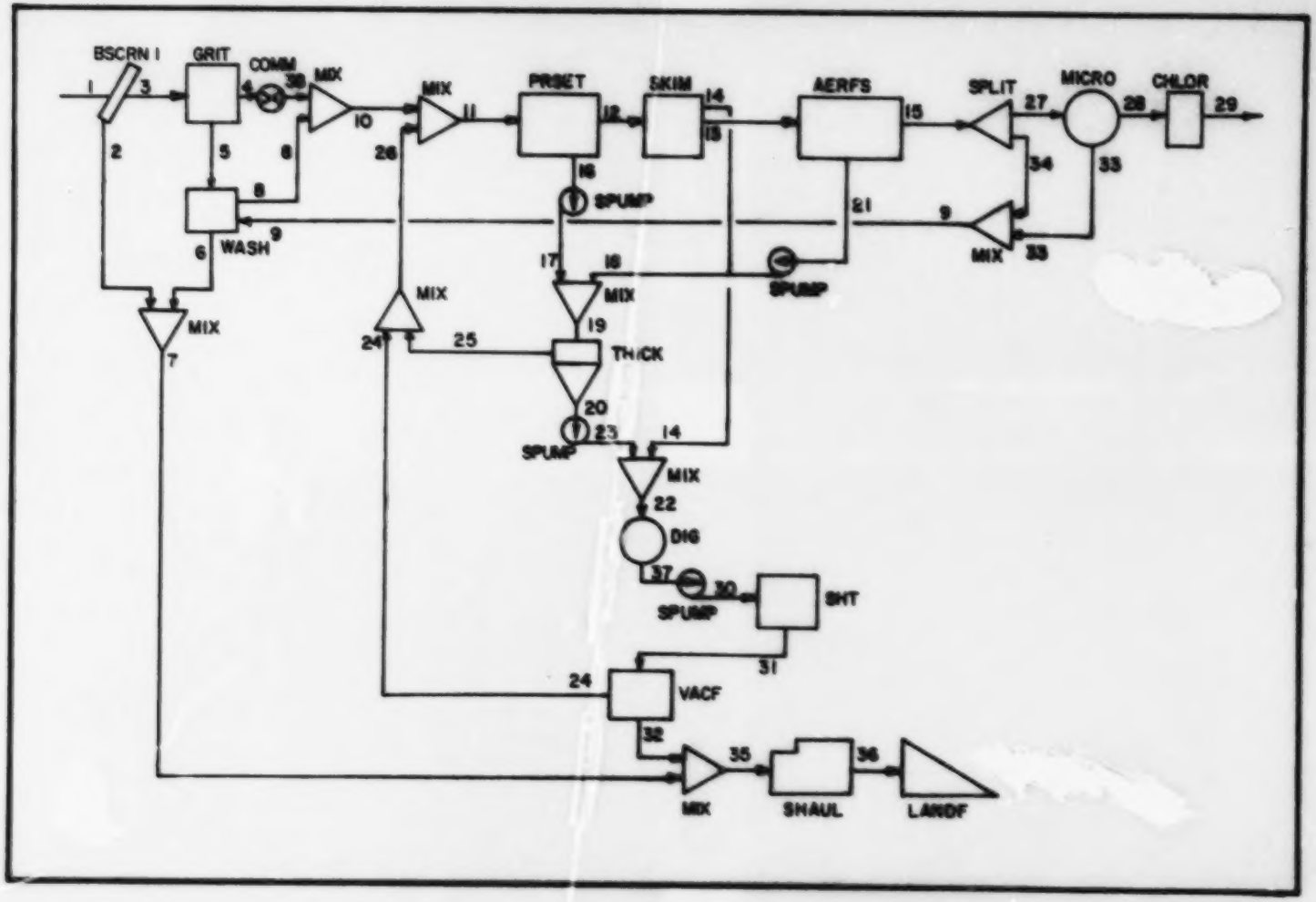


Figure 7: Process Diagram, Recommended Springfield Treatment Plant for Ground Refuse Handling

DIGITAL COMPUTER PROGRAM
FOR
PRELIMINARY DESIGN OF WASTEWATER TREATMENT SYSTEMS

BY
GEORGE R. FISETTE

CURRAN ASSOCIATES INC.
182 MAIN STREET
NORTHAMPTON, MASSACHUSETTS 01060

SPRINGFIELD,RECOMMENDED PLANT FOR GROUND REFUSE TREATMENT,2.25 LB/CAP/DAY

SYSTEM FLOW SCHEME
INPUT DATA

K	V	PROCESS		IS1	IS2	OS1	OS2	III	MREAD
0	1	3	TSCRNI	1	0	3	2	2	0
0	2	9	GRIT	3	0	4	5	2	0
0	7	11	COMM	4	0	38	0	2	0
1	0	13	MIX	38	8	10	0	1	0
2	0	13	MIX	10	26	11	0	0	0
0	3	15	PRSET	11	0	12	16	0	0
0	4	53	SKIM	12	0	13	14	0	0
0	5	16	AERFS	13	0	15	21	0	1
0	6	56	SPUMP	16	0	17	0	0	0
0	16	56	SPUMP	21	0	18	0	0	0
0	0	13	MIX	17	18	19	0	0	0
0	8	34	THICK	19	0	20	25	0	0
0	17	56	SPUMP	23	0	23	0	0	0
0	0	13	MIX	23	14	22	0	0	0
0	9	37	DIG	22	0	37	0	0	0
0	18	56	SPUMP	37	0	30	0	0	0
0	19	36	SHT	30	0	31	0	0	0
0	10	40	VALF	31	0	32	24	0	0
2	0	13	MIX	24	25	26	0	0	0
0	0	14	SPLIT	15	0	27	34	0	0
0	14	27	MICRO	27	0	28	33	0	0
0	0	13	MIX	33	34	9	0	0	0
1	11	10	WASH	5	9	8	6	1	0
0	0	13	MIX	2	6	7	0	2	0
0	0	13	MIX	7	32	35	0	2	0
0	12	58	SHAUL	35	0	36	0	2	0
0	13	45	LANDF	36	0	37	0	2	0
0	15	33	CHLOR	28	0	29	0	2	0
0	0	0		0	0	0	0	0	0

PROCESS 3.ITERATION 1
STREAM 3 MGD 64.400 TSS 1508.8

STREAM 2 MGD 0.000 TSS 700000.1

PROCESS 9.ITERATION 1
STREAM 4 MGD 64.383 TSS 1043.8

STREAM 5 MGD 0.016 TSS 1857144.0

PROCESS 11.ITERATION 1
PROCESS 13.ITERATION 1

PROCESS CHARACTERISTICS

CCOST = CAPITAL COST, DOLLARS
COSTO = OPERATING + MAINTENANCE COST, CENTS/1000 GAL.
ACOST = AMORIZATION COST, CENTS/1000 GAL.
TCOST = TOTAL TREATMENT COST, CENTS/1000 GAL.

TOTAL PLANT COST

TOTAL CAPITAL COST = 31629120. DOLLARS

TOTAL AMORTIZATION COST = 10.526 CENTS/1000 GAL.

TOTAL O & M COST = 6.660 CENTS/1000 GAL.

TOTAL TREATMENT COST = 17.186 CENTS/1000 GAL.

CCI	WPI	RI	YRS	DHR	PCT	DA	CCINT	XLAB
176.100	120.000	3.000	25.0	3.50	0.150	1000.	0.06	1.00

RATIO	TCAP	YARD	TCC	XLAND	ENG	SUBT1	FISC	SUBT2	XINT
1.312	23754000.	3329561.	27079563.	54716.	1604703.	28938992.	81017.	29020000.	2609226.

ACRE	AF
54.72	0.07823

		CCOST	COSTO	ACOST	TCOST
ADMINISTRATIVE AND LABORATORY		522406.	0.236	0.174	0.410
GARAGE AND SHOP		174017.	0.0	0.058	0.058
LABORATORY OPERATION	XLAB 1.0	0.	0.166	0.0	0.166
YARD OPERATION		0.	0.180	0.0	0.180

P 1 BAR SCREEN NO.1

FGSSR	SOLIDS	VELH2O	ABS	SCREEN
0.100E-01	70.0	2.00	49.8	37.4

	CCOST	COSTO	ACOST	TCOST	ECF
PURCHASE	25878.	0.001	0.009	0.009	1.50
INSTALL	6469.				

P 2 GRIT CHAMBER AERATED

FLNGTH	FSHORT	WDIST	ORGAN	DENSIT	FGSS	FTHR	FTMG
0.55	0.25	0.35	0.40	80.00	0.75	200.21	74.61

	CCOST	COSTO	ACOST	TCOST	COSTO	ECF
	24034.	0.001	0.008	0.010	1.00	

P 3 PRIMARY SETTLER

FRPS	URPS	HPWR	GPS	APS	PGPM	FGSSR	FGRITR
0.60	90.0	108.0	308.4	295.502	537.	1.00	1.00

	CCOST	COSTO	ACOST	TCOST	ECF
SETTLER	3819990.	0.129	1.271	1.400	4.00
SLUDGE PUMPS	153092.	0.070	0.051	0.121	1.00

P 4 SKIMMER

KLM	WI	FRACVS
1.00	0.20	0.70

P 5 AERATOR-FINAL SETTLER

						CCOST	COSTO	ACOST	TCOST	
	BOD	ALOS	DFOF	CAER20	OO	0.0	0.0	0.0	0.0	
	30.0	2000.	20.00	1.00	1.00	AEFF20	URSS	GSS	HEAD	
	SOO2	DOSAT	ANSS	AFS	CAER	0.05	3.00	667.00	30.00	
	152.2	10.0	0.0102	462.37	1.00	CEOR	VAER	VNIT	MLASS	MLOSS
	MLNASS	MLOSS	MLISS	FOOD	RTURN	0.125	18.883	29.664	500.	426.
	500.	9.	680.	92.0	0.445	CNIT	ARCFO	BSIZE	CFPGL	AEFF
						0.321	39733904.	96575.	0.62	0.05

	CCOST	COSTO	ACOST	TCOST	ECF
AERATOR	3404250.	0.0	1.153	1.153	3.50
BLOWER	2748958.	0.875	0.915	1.790	3.50
SLUDGE PUMPS	1116339.	0.207	0.372	0.579	3.50
FINAL SETTLER	5903234.	0.192	1.965	2.157	3.50

P 6 SLUDGE PUMP

ECF	GPM
536.53	0.0

P 7 COMMINUTOR

HRDY
26.00

CCOST	COSTO	ACOST	TCOST
170530.5	0.07	0.06	0.13
CCOST	COSTO	ACOST	TCOST	ECF
72107.	0.002	0.024	0.026	1.00

P 8 GRAVITY THICKENER

DR	TSS	QIN	QSTH	ATHM	HRT
0.95	120000.0	293.0	11.0	71370.0	0.00

								CCOST	COSTO	ACOST	TCOST	ECF
								1092378.	0.098	0.364	0.459	1.50
P 9	ANAEROBIC DIGESTER	TD	RDIG	CIDIG	C2DIG	VDIG	CH4	CO2				
		15.0	60.0	0.234	1154.	1032.	896428.	470781.				
							CCOST	COSTO	ACOST	TCOST	ECF	
							2683958.	0.232	0.893	1.126	1.00	
P10	VACUUM FILTER	VFL	dPAA	TSS	IVACF	FECL3	HP	AVF				
		10.50	10>.	200.	1.00	9.07	74.9	7756.7				
							CCOST	COSTO	ACOST	TCOST	ECF	
							5148230.	1.590	1.713	3.303	2.50	
P11	GRIT WASHER AND DEWATERER	DENIN	RATST	DENOUT	FTHRF	FTHRP	TWTR	CAP	HRDY			
		90.00	0.10	100.00	130.14	69.56	********	144.00	21.69			
					ACOST	TCOST	ECF					
							15978.	0.001	0.005	0.006	1.00	
P12	SLUDGE HAUL	TCAP	DIST	SPEED	CPPU	RHOUR						
		40.00	10.00	25.00	30.00	13.00						
							CCOST	COSTO	ACOST	TCOST		
P13	LANDFILL	CLAND	DEPTH	DPCPT	YEAR		0.0	0.48	0.0	0.48		
		1000.00	6.00	3.00	0.0							
							CCOST	COSTO	ACOST	TCOST		
P14	MICROSCREEN	ADJOUT	REFAC	HEAD	RPM	FABRIC	WASRT					
		0.0	3.270	6.00	4.00	1.00	0.500E-01					
		AREA	UNITS	CECF	TOTHOD	ECF						
		0.641E 04	20.+	1.27	24.9	1.00						
							CCOST	COSTO	ACOST	TCOST	CECF	
							2764287.	0.514	0.920	1.434	1.27	
P15	CHLORINATION	DCL2	TCA2				CCOST	COSTO	ACOST	TCOST	ECF	
		10.0	30.0			FEED SYSTEM	309834.	0.617	0.123	0.740	1.50	
						CONTACT BASIN	459847.	0.0	0.153	0.153	1.50	
P16	SLUDGE PUMP	ECF	GPM									
		1459.40	0.0									
							CCOST	COSTO	ACOST	TCOST		
							357527.5	0.11	0.12	0.23		
P17	SLUDGE PUMP	ECF	GPM									
		346.42	0.0									
							CCOST	COSTO	ACOST	TCOST		
							133577.8	0.06	0.04	0.10		

P18 SLUDGE PUMP ECF GPM
357.47 0.0

	CCOST	COSTO	ACOST	TCOST	
	136154.1	0.06	0.05	0.10	
P19 SLUDGE HOLDING TANK	CCOST	COSTO	ACOST	TCOST	ECF
TD 1.5 VOLT 103.2	257574.	0.053	0.086	0.138	1.00

ITEM# 2

CHAPTER V

RECOMMENDATIONS

In view of the limitations imposed by the specific aims of the contract under which these program modifications were developed, it has not been possible to produce a finished and completely documented product. In particular, the following work items are recommended for further EPA support:

1. Additional program versions should be developed to allow execution on systems other than the IBM 360-DOS (Disk Operating System). In particular, a version should be provided for IBM 360 under OS (which would also allow execution on IBM Series 370), and for the IBM 1130. These two additional versions for widely available computer systems would make the program available to a correspondingly wide spectrum of potential users. Some rewriting would be necessary as the program presently contains numerous features specific to the 360-DOS system.

2. A comprehensive documentation manual should be prepared, synthesizing the earlier documentation by Smith and Eilers with the supplementary material contained in this report, and including detailed descriptions of all the unit processes modelled, including those of other EPA contract research projects.

3. Those subroutines still in incomplete form should be completed and documented.

4. A comprehensive program of verification should be undertaken, testing all routines under a wide range of expected operating conditions.

Completion of these items would result in a complete comprehensive computer package that would be of wide interest to federal and state agencies, consulting engineers and research scientists involved in the planning and evaluation of cost-effectiveness of wastewater treatment facilities. The level of effort for these completions is estimated at between 6 and 12 professional man-months.

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16. Teletyke, G. H., "Wet Air Oxidation of Sewage Sludge," Transactions of the Sixteenth Annual Conference on Sanitary Engineering, The Bulletin of Engineering and Architecture No. 56.

APPENDICES

Because of the extreme length of the appendices (over 250 pages) they have been omitted from this report copy. The following appendices, and Card Deck, can be obtained on request from the writers.

Appendix A: Program Listing (about 200 pages)
Appendix B: List of Input Parameters (about 30 pages)
Appendix C: List of Output Parameters (about 20 pages)
Appendix D: Coding Sheets (1 page)
FORTRAN CARD DECK (about 12,000 cards)
JOB CONTROL CARDS FOR IBM 360 DOS (about 60 cards)